

**Interaction style and specification of the
occasional user of digital interfaces:
perspectives from interdisciplinary assessment
of virtual agent spatial guidance**

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Declaration

I, Santiago Martinez, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I can confirm that this has been indicated in the thesis.

Signed



Date 19/5/2014

Chapter 7

AGILE Interface for 'No-Learning nor Experience required' Interaction²⁹

The aim of this chapter is to describe a formal exercise of asking several users to perform a complete transaction in a way that reveals aspects that the development team could not anticipate. The difference between the approach presented in Chapters 4,5 and 6 and the one presented in this chapter lies on the methodological variation applied: experimental design versus a case study of two cycles of iterative design. Although this method will produce a quantitative comparison of interaction times between two alternative UI one novel and another existing UI, this is not main objective of the exercise. The overall aim of the exercise is to subject the new UI to a formal comparison process. This process, coupled with its reference UI, sheds a necessary spotlight on the development process to identify areas in need of improvement and areas of merit. It is not possible to anticipate what aspects of a design will work with a new interface and a new user group, and the risk of a confirmation bias in informal evaluation is high. In particular, the risk is increased if the user group is not of the same demographic sample as the design group. In the absence of an ability to simulate or empathize with a niche user group, it is quite possible to make design errors.

²⁹ Aspects of this chapter have been reported in: Chapter 5 of the Springer book on "User Modeling and Adaptation for Daily Routines": *AGILE Interface for 'No-Learning Nor Experience Required' Interaction*. In *User Modeling and Adaptation for Daily Routines* (Martinez *et al.*, 2013); and in *Occasional User* (Carrillo *et al.*, 2013).

The experimental methodology and apparatus used in explanatory experiments is of use in the design cycle iteration here. In particular by setting up a formal comparison exercise, the researcher is focussed on the control of as many experimental variables as possible, to ensure fair comparisons between participants and across conditions. To establish the nature of the interaction experience of the user, the use of an eye-movement recorder is again incorporated. In this case, the purpose is to confirm what elements of the UI are fixated by the user, but also to establish what if any design elements are not fixated or seen by the user.

One element of experimental design from experiments 1-6 that is absent here is the use of repeated measures. Whilst in an explanatory experimental set up, repeated measures serve to increase statistical power, in a design cycle phase oriented on error detection, the goal is not to only to quantify the errors, rather it is to identify the errors. The nature of the evidence required for this is rather different. If an error is found, even once, then it must be dealt with in the next design cycle: the hypothesis that the operation of the UI is 'error free' is immediately rejected in these cases. Just as a black swan immediately eliminates the hypothesis that all swans are white.

7.1 The Occasional User: characteristics and variables

The increasing weight of usability and accessibility in the design of digital systems is parallel to the proliferation of new types of devices and new scenarios of use (e.g., mobile devices such as smartphones and tablets; Self-Service Technology (SST) such as self-service checkout (SSCO) terminals in shops or Self-Service Check-in (SSCI) terminals at airports) that

redefine the traditional relationship between user and technological devices. User's interactions are no longer based only on simple data process/extraction. Instead, rich interactive dialogs present quite different goals such as: buying tickets in a train station ticket machine, obtaining a boarding pass at airport-check in machine, a first-time web transaction or being guided to the nearest located ATM by a specific-purpose mobile application.

This type of interaction can be described as occasional (Martinez *et al.*, 2013), and Occasional User (OU) who carried it out. The OU (Carrillo *et al.*, 2013) is a type of user without previous experience nor knowledge about a specific interface and whose main priority is to use the system to achieve their goals with minimum cost on time and effort. The key points of OU interaction are guidance during the process and assistance in case of error, without requiring from the user a previous knowledge to use the interface. For that, spending time in learning how to use the interface is futile as they ignore if they are going to use the interface again in the future.

An OU is defined by the goal/s that trigger the HCI. These users are unfamiliar with the use of the digital interface, and do not have time to learn by the traditional way of repeating use of the same interface. An OU has only the time that the interaction elapses to know how to use it (see Table 14). There is no need nor expectation of any repeating use of it in the near future, what impedes the learning by retention or accumulated experience. All these features result in an appropriate definition for the occasional use of an unfamiliar interface that is applicable in a wide range of contexts.

Table 14

| <i>Occasional User Characteristics</i> | |
|--|--|
| 1 | Very specific goal/s to accomplish |
| 2 | Unfamiliar with the application and its interface |
| 3 | Do not have previous knowledge of training on the interface or analogous that is to be used |
| 4 | Only have the time the interaction elapses to know how to use the system |
| 5 | Do not have any ambition to master the system because their priority is to accomplish their goal |
| 6 | No prospective use of the interface in the near future, neither time for learning by retention or accumulated experience |

Accordingly, two parameters associated with time are critical in understanding the OU: *experience* on the interface and *prospective use*. The former, experience and knowledge on the interface, identifies the prior experience the user has with the interface. In case of occasional use the value is zero or near zero. This means that whether the user has had an encounter with the same or analogous technology, the difficulties they experience on learning and, in many cases, their absence of motivation, make it unwise to rely on user memory recall as the sole mechanism to recognise how to use the interface. It is worth emphasising that the user, then, faces an unknown interface. The other variable, prospective use, is an explicit reference to the probability of the use of the same system by the

same user in the near future. The likelihood of future use of an interface by an OU cannot easily be inferred. The probability is constrained to be always less than 1 and, in terms of the implications of design for learning that will be discussed below, any individual session the OU has with the interface should be assumed to be unique (see Table 15).

Table 15

| <i>Identification Parameters and their values for OU</i> | |
|--|---|
| Experience and knowledge on the interface | ≈ 0 |
| Prospective use | $0 \approx P(\text{prospective use}) < 1$ |

Note. P = probability

7.2. Implications of OU parameters in Interface Design

The selection of these variables has several important implications in the UID and interaction for the OU in terms of *Learnability*, *Goalability*, *Elapsed Time*, *Guidance and Assistance*, and *Recovery and Error handling* (see Table 16).

Table 16

Implications for User-Interface Design for Occasional Users.

| | |
|-----------------------------|---|
| Learnability | the number of sessions the same user is going to perform is supposed to be 1. This means that possible future interactions are not accounted for. Mechanisms of learning functionalities of the interface, by retention, or by repetition, are limited. Instead of relying on the user to learn how to use the system, it is recommended to show the user how to achieve their goals. For it, the use of analogy mechanisms, such as metaphor (Carroll, 1982), are essential to establish intuitive representations of interface elements and links with the real world elements. |
| Goalability | the importance of the achievement of user's goal/s, which is the ultimate reason that explains why the OU is using the interface. Above all, the allowance and the path to achieve any goal and sub-goal should be described guiding the user where necessary, minimising the ambiguity and error probability. |
| Elapsed Time | the time that a user spends in using the interface to achieve their goal/s, or, in other case, to receive a helpful outcome from the system. Possible increments on time spent should be only allowed to ease the interaction, goals or assistance, e.g, extra screens, or dialogue with a virtual assistant. |
| Guidance and Assistance | efficient mechanisms of guidance through the interaction should be provided. This aspect compensates the deficiency on the learnability mechanisms described. For example, a dynamic virtual assistant would lead the user throughout the interaction, informing in each step (e.g., Martinez <i>et al.</i> , 2013) in a similar way that other software applications, such as assistants or wizards, do during the installation of a software application. Another recommendation would be to present a clear map of the interaction steps, informing the user about the progression of the process. |
| Recovery and Error handling | effective help system in case of error or impossibility to achieve a goal. It relates with user's feedback, and will influence the notion user takes from the interaction process. |

In summary, OUs are generally unaware of the low level details of the system about to use (e.g., software version, use of emoticons, customisable look and feel). Therefore OU's expertise requirement should be removed from the preconditions imposed in the development of these interfaces. The potential benefit of designing for these users is that the interfaces can be potentially used by users from a wide range of expertise. The OU inherent characteristics of memory and learning require an interaction designed with agile mechanisms that make cognitively inexpensive UI use.

7.3 Target OU group: Novice elderly users

Based on an inclusive paradigm, the goal of this chapter is to improve the usability and satisfiability of the interface for a specific group of OUs to benefit all types of users in their daily lives. The target OU group chosen is the novice elderly user who, for their idiosyncrasy, add an interesting challenge for designing interfaces for them.

The current technological panorama presents a wide variety of devices that may act as a barrier to satisfactory usage and learning. For instance, it is common to find that different types of interface layouts and different functionalities, even in the same category of products under the same brand, can steepen the learning curve for an effective device operation. Interface design can homogenize this technological environment diversity to a user covering their specific needs and substantially improving their performance, satisfaction and life. As an example of this, the requirements derived from a holistic analysis of target users' goals and context of use lead to the

introduction of the proposed *AGILE Interface* (Assisted Guided Interaction with no Learning nor Experience required).

7.4 What is AGILE?

AGILE is the acronym of Assistive Guided Interaction with no Learning nor Experience required. The name is similar to the AGILE Software Engineering methodology (Fowler & Highsmith, 2001). They have in common the iterative design typical of any user-centred interface design. Beyond that feature, there is no inspiration or relationship between the two terms.

AGILE is an assistive interaction style for a digital transaction without requiring previous learning of how to use the interface. The benefits of this type of interaction are reflected on its interface, designed to improve the performance, satisfaction and life of OUs, such as novice elderly, whose distinctive requirements demands an adequate User Interface Design (UID). The goal is to move beyond out of date user stereotypes to tailor appropriate interface design adapted to realistic and specific user demands.

7.4.1 AGILE Fundamentals

The new proposed methodology based its rationale on four pillars. First, the environment plays a role as another actor in the interaction process, at the same level of importance as the interface. The elements of the environment relevant for the interaction in course should be part of the interface (e.g., chip and pin device in a SST transaction, emergency exit in a flight evacuation), becoming components of the narrative included in the interface design. Second, the amplification of user's inherent capacity thank

to the new interface that simplifies the interaction steps and reduces the cognitive load of the decision-making. Third, the methodology presents a static adaptation of the modeled user developed during the design stage. Fourth, the type of use addressed by this methodology is described as OU, looking at this specific type of user shaped by adequate parameters, whose values directly influence UID.

7.4.2 Process of Adaptation for novice elderly users

Traditionally, adaptive interfaces have been focused on a series of selected elements to build up the adjustment of the interface during their usage. Brusilovsky and Millán (2007) reviewed the five most popular features to be considered in adaptive web systems as well as how to model the context of user's work. The authors presented the *Knowledge* as the understanding of the subject being taught or the domain represented by the system. It was a changeable feature by *learning* (increased) or *forgetfulness* (decreased), from session to session or even in the same session. *Goals* represented what the user wanted to achieve, and they were catalogued in a way that they were recognizable by the system. *Background* constituted a set of features related to the user's previous experience outside the core domain of a specific web system.

These considerations have a direct implication for AGILE. The particular feature of variance of user's knowledge depending on the learning process involved in interface use and on the memory functioning applies straightforwardly to elderly users. Goal and task hierarchy follow this line of research and are a central part of the AGILE interface, showing only the

minimum information necessary to be understood and used to accomplish a goal across the variability of possible backgrounds.

Inside the *Individual Traits*, Brusilovsky, and Millán (2007) included *Cognitive* and *Learning* styles. The former affected the way information was organized and presented, the latter the way people preferred to learn. Both components are used in the new style presented, but conveniently modified for the specific target users. That is, the presentation and organization of the information is simplified as much as possible and the learning requirements are minimal.

Regarding the *Context of work*, it also applies to the new style in the form of the environment and human dimensions. The environment dimension refers to the physical context around the user, which plays a vital role during the whole interaction process, becoming another part of the interaction itself. The human dimension contained the important feature of cognitive load, taken into account in the design of the interface.

In conclusion, all these features presented above are a starting point for the construction of a new interaction style suitable for novice elderly users. The adaptation process is therefore applied in the design stage. Firstly, there is an adaptation of contents, where only elements relevant for the user interaction are shown in the interface. The purpose is to reduce to a minimum the distractions that can waste user transaction time during irrelevant inspection or meaningless interpretation of such elements. Secondly, the adaptation occurs in the guidance system employed. There will be an appreciable area dedicated for the guidance system, responsible for directing user's attention to the interactive interface elements in each transaction's

step. Finally, mechanisms of assistance will provide user with procedures to be helped and amend information in an effortless way. This approach could be seen as a cross-adaptation process in terms of the adaptive presentation and adaptive navigation support that Brusilovsky (2001) used in the taxonomy of adaptive hypermedia methods and techniques, but placed in a static fashion in the interface design stage.

7.4.3 Specific parameters and their values for novice elderly user

As specified in Chapter 2, the wide variety of digital transactions involve new types of users and scenarios. It is relevant to place the elderly user without experience in the spectrum of occasional users of digital transactions, with defined respective characteristics and variables initialised.

As discussed above, the proliferation of new contexts of use and technologies have transformed digital transactions in something more refined than simply data extraction. They represent interactions for different goals such as buying a ticket in a train station ticket machine, scanning a passport at the airport, a web transaction for first time, etc. A novice elderly user is a type of user with the same incentive to learn than one-time users (i.e., a user who uses an interface only once in a lifetime). Anecdotal evidence suggests that they are likely to say:

“I am too old to learn new skills.” (Newell, 2006)

Their cost of learning is increased because their time to acquire new skills is higher compared with a younger population with non-degraded cognitive skills. Consequently for elderly users, the cost and motivation of learning is the first serious obstacle to successful use of the same technology in the

near future, on the contrary an easier task and common incentive for younger users. Hence, they may not have interest in any fine details of software or hardware, and so their motivation for such use can be only increased by didactical and guided methods. As an OU, guidance during the process, assistance in case of error and demonstration of goal achievement are the core of the interaction for this type of users (as seen in section 7.2). Even if a sufficient level of learning of how to use the interface is achieved, subsequent future use, if any, should be considered as 'first' in terms of memory and functionality recalling.

A set of relevant variables and their values related with such technology use can be seen in Table 17.

Table 17

Parameter, Description and Values for Novice elderly user.

| Parameter | Description | Value |
|------------------------------|---|--|
| Motivation | reason that triggers the use of the system | very low or none. The purpose and benefits are carefully explained |
| Familiarity | user's acquaintance of the interface and analogous systems | very low or none, typical of novice users |
| Skill level | capability to use technology in general or computer related systems in particular | very low or none, typical of novice users |
| Cost of learning use | effort necessary to achieve a sufficient level of knowledge to use the interface | high or very high, a characteristic of elderly users due to their cognitive limitations or deteriorations by age |
| Learning procedural aspects | request for a user to learn methodical aspects in order to satisfactorily use the system | it is in dependency of the AGILE interface implementation |
| Experience with interface | the prior experience the user has with the interface | none or almost none, typical of OU |
| Frequency of prospective use | probability or guarantee about the use of the same system by the same user in the near future | none or very low, as established for an OU |

7.5 AGILE Model: Assisted Interaction with No Learning nor Experience Required

This model is addressed to cover the gap existent in the research for occasional interactions, those without a prospective use assured. The model incorporates into the design stage elements to reduce the cognitive load in the decision-making steps of the interface use. Additionally, the interface offers a consistency along throughout its use, presenting simple elements that became easily recognizable even for an infrequent user. In summary, a harmony and coherency between the interface elements, messages and goals that provide an effective and easy-to-accomplish digital transaction.

7.5.1 Philosophy

To elaborate on AGILE, a new interaction style is presented based on the hierarchical task analysis and namely AGILE Interaction. It pursues the ease of use, but takes into account the lack of traditional mechanisms of learning by repetition or retention. This style sacrifices the possibility of developing the execution of processes in parallel and other typical advantages of WIMP (windows, icons, menus, pointer) interfaces (Van Dam, 1997). It works towards simplifying the syntax of knowledge to optimize system use and its semantics³⁰. The user should be able to interact without a previous intensive study of them. Semantics should be sufficiently intuitive to allow the user to correctly interpret the interface structure with a minimum effort.

Thus, the interface essentially contains short but meaningful descriptions with concise language and meaningful content. An effective approach to

³⁰ The terms *syntax* and *semantics* understood as described by Shneiderman & Plaisant, 2005, p. 86

develop this concept is a correct and effective use of the metaphor (Carroll, 1982). The metaphor is a pillar of any current UID. It is, in essence, a vehicle to transfer a concept, knowledge or idea to the user. In the context of users with no experience and reduced cognitive function, such as elderly, this transference becomes critical to effectively transmit, interpret, and reorient if necessary, the meaning that the metaphor represents. As a consequence, the metaphor can include a new dimension of literality to achieve a correct use of the AGILE interface. This literality will be introduced by two elements: a virtual agent (VA) will represent the assistant part of the interface, explaining and indicating the options in each step. The second element will be, wherever possible, a representative icon of the option accompanying the text. These two elements represent the faithful connection between the explanations and decisions making inside the interface with the world outside the interface.

7.5.2 Learning from Traditional Interaction Styles

Traditional interaction styles may bring some useful characteristics to put up a suitable interaction style for the elderly user. For instance, direct manipulation (Hutchins, Hollan, & Norman, 1986; Shneiderman, 1983) is already placed in almost any interface in greater or lesser extent. The immediate handling of objects is primarily connected with how an object is seen and used in the world and it becomes a critical feature of this new interaction style. In addition, the active component of *questions and answers* (Nielsen, 1993; Rogers, Sharp, & Preece, 2011) and the tutored approach of the *wizards* (de Jesus Stoll & Wickham, 2005) make them very

commendable for elderly users. Other features from other styles such as *form filling* should be used only when absolutely necessary (e.g., authentication with introduction of password), and even in those cases any alternative with the same effectiveness and minimum text input should be examined. For instance, the interface should offer better ways to deal with the information than the traditional typing, where the environment allows to it (e.g., if the source of target destinations for a trip is publicly available, a predictive search considering the default location where the user currently is, will save time and effort). *Command language* is manifestly discarded for lack of experience and the complexity and time required learning how to use it.

7.5.3 Implication for User-Interface Design

To overcome the habitual lack of Inclusive Design of part of ICT designers (Glinert, & York, 1992), this work is oriented to prevail over functional limitations of users (Hyppönen, 2001). This perspective incorporates in the UID what it is relevant for user with specific requirements: the capacity of doing an assisted and guided definite task. Based on the variables previously described and taking on board their implications for designing, the specific aims of this methodology are:

- (1) Simplifying the decision making on every transaction step.
- (2) Guiding the user in all the steps of the interaction process.
- (3) Assisting and demonstrating the use of interactive components on the interface.

To simplify the decision making, there is a transformation of the task tree structure, flattening its depth to transform the transaction in a process with

greater number of decision steps but with lower complexity in each decision. Many times in digital transactions, the steps are overloaded with multiple decisions that impair the understanding of the next step in the interaction process, especially during first-time use.

To achieve those aims, first a VA implements the personification of the assistance concept. Using the animation principles outlined in the experiments from previous chapters, quick and effective demonstrations of 'what to do?' and 'how to do it?' are shown by the VA. In addition, user's attention is directed to relevant items and areas of the interface by head, gaze cues and gestures of the agent. This paradigm is based on multi-frame animated physical cues used to orient attention of the user (Chapter 5; Martinez *et al.*, 2010) on digital and touch interfaces (Chapter 5; Martinez *et al.*, 2012) in combination with animation principles to predict perception on the observer (Chapter, 6; Sloan, Martinez, & Scott-Brown, 2012). In the following Table 18, principles are stated on the right as potential resources for the design of the interface and are used with discretion over iterations of the interface design. Deficits associated with the age are stated on the left.

Table 18

| <i>Elderly User deficits and applied principles</i> | |
|--|--|
| Deficit | Applied Principles |
| Attention | simple layout; physical cues (Chapter 4; Chapter 5; Martinez <i>et al.</i> , 2011; 2012); animation principles (Chapter 6; Sloan, 2011a) |
| Touch | touch screen, customizable size of items, input redundancy: mouse track pad, keys, phone (Chapter 4; Chapter 5; Martinez <i>et al.</i> , 2011; 2012) |
| Reading | avoid meaningless text buttons, use icons, speakers |
| Vision | animation principles: exaggeration, silhouette (Chapter 6; Sloan <i>et al.</i> , 2012) |
| Sound | text and sound, indications, flashes |
| Emotion | simple, exaggerated characters (Chapter 6) |

7.5.4 AGILE initial prototype description

A selection of the applied principles described in Table 18 are employed in the AGILE interface design. The initial prototype divided the screen into four different areas of interest in a landscape screen mode (see Fig. 41).

- a) *Goals’ Map*: this area is placed in the top of the screen. Its purpose is to show the hierarchy of active goals in each

moment. It starts showing the immediate goal to achieve (e.g., goal A), and a sequence of current goal's sub goals (e.g., goal B, goal C). This area is not intended to allow any type of interaction. Thus, its role is merely informative.

- b) *Steps' Map*: it contains the sequence of steps necessary to accomplish the current goal. Steps are ordered, sequenced and numbered. However, there is only one step activated at any time (noted by bold font type), rest of the steps appears deactivated (noted by a non-bold font type).
- c) *Assistance area*: a VA (a female assistant character was chosen for this prototype) who would be in charge to point out which is the current step. The VA's main aim is to assist in the use of the interactive components of the interface. It is also a vehicle to orient the attention of the user to the relevant areas of the interface, where the demonstration or subsequent interactivity would occur. This area is intended to receive interaction from the user in order to confirm the finalization of the step (all the interactions inside that step are accomplished and finished by the user).
- d) *Interaction area*: the area designed to receive most of the physical interaction from the user. It also shows the information relative for the interaction flow (physical layouts, measures, etc). Item selection, form filling and direct manipulation would occur in this area.



Figure 41. Scheme of the first prototype of AGILE interface, shown in a tablet. (a) Goals' Map, (b) Steps' Map, (c) Assistance area and (d) Interaction area.

7.6 AGILE Prototype Evaluation

Following the User-Centred Design (UCD) approach, an evaluation of the two iterations of the AGILE prototype interface was made.

7.6.1 AGILE prototype evaluation methodology

The first iteration of the AGILE interface prototype was tested to observe, ask to and interact with users in order to provide a better understanding of the possible mistakes, potential improvements and informal subjective participant evaluation of the effectiveness of the interface prototype. The evaluation was distributed in three different parts. Firstly, the developing of an interface with the aims previously introduced: simplification of decision making and guiding the user in the use of the elements of the interface.

Secondly, the interface was tested on a digital transaction that users occasionally perform in the physical world, such as buying a train ticket or alternatively buying a book. The device chosen was a portable device (tablet) and touch input channel. Target users were novice elderly, with little or no experience on touch and technological devices such as computers.

Thirdly, the iterative design and test of such interface was based on the analysis and conclusions obtained from the evaluation.

7.6.2 Iteration 1: AGILE prototype in MS Power Point with Human assistance

This iteration was aimed to provide an early evaluation of the AGILE interface prototype developed, specifically to see where the participants had problems interacting with the interface elements and if they got blocked in any specific step. The first iteration of the prototype consisted of a preliminary evaluation of a MS Power Point (MS Power Point 2008 for Mac, v. 12.1) presentation shown on a PC, about a Kitchen Design application (see Fig. 42), inspired by the IKEA (2012) kitchen planning tool. The number of participants was four, with an average age of 74 years (see Table 20, p. 231, to see participants' profiles). They gave informed consent from the Computer Science Languages and Systems department from the University of Malaga, Spain. Participants were not disabled and their cognitive abilities were typical of that age, with no special impairments described. Prior to the start of the exercise they were interviewed to establish their self reported previous exposure level to new technology. Table 19 shows the categories of technology used as prompts in the dialog.

Table 19

Self-report Technology Categories

| Technology |
|---------------------------------|
| None |
| Landline with dial |
| Landline with touchtone buttons |
| TV |
| VCR |
| Microwave |
| PC |
| Mobile Phone |
| Smartphone |
| Tablet |

They were instructed to build their own kitchen using the application. The researcher would assist the participant only if they were stuck for a certain time in the same step, or operation.

Table 20

Participant Profiles Iteration 1

| Partici pant | Ag e | Gen der | Nation ality | Assist . | Newest Technol ogy Use |
|-----------------|---------|------------|-----------------|--|--|
| 1 | 76 | Male | Spanish | Glasses for short distance | Mobile phone |
| 2 | 73 | Female | Spanish | | Mobile phone |
| 3 | 72 | Female | Spanish | | TV/VCR |
| 4 | 75 | Male | Spanish | Glasses for short and long distance | Landline phone with touchtone buttons |

Note. Assist. = Assistance

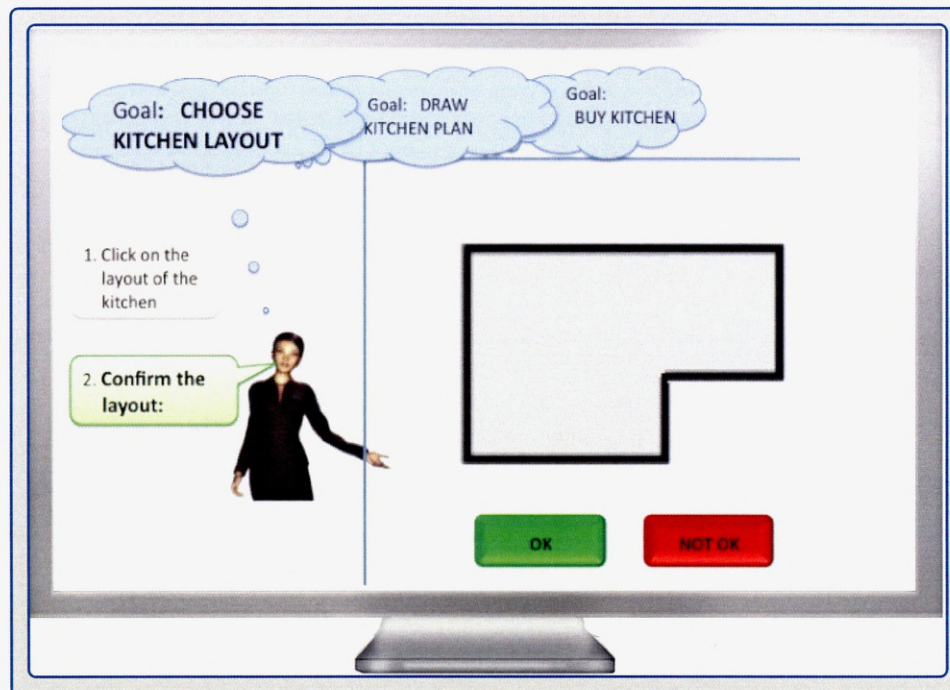


Figure 42. First prototype of AGILE interface, shown in a PC with MS Power Point. It can be appreciated, from left to right and top to bottom, clouds with name of goals (Goals' Map); speech bubbles (Steps' Map); a virtual agent (Assistance area) and a confirmation task (Interaction area).

The total number of steps (slides) presented was eight. Controls were set up to advance to the next slide whenever the user selected an available option. When the user got 'stuck' in any step, the researcher helped, carefully explaining how to perform the corresponding action. Typically the most common problem was how to do a selection (press a specific button), when there was more than one element active on the screen.

Conclusions from observations on this iteration showed that the Goals' Map was not seen nor useful for interface use. Instead, it was disturbing normal interaction because when participants were asked if they perceived it, only two of them did so and they did not find it meaningful. The same

happened with the Steps' Map, which was getting in the way when users thought they had to click on the speech bubbles, disrupting the interaction instead of informing it. The trend from the user was to think that every element appearing on the screen was *clickable* and relevant for the current task, instead of distinguishing what was informative and what interactive.

7.6.3 Iteration 2: AGILE prototype on an iPad2

The aim of this iteration was to evaluate the evolved prototype of an AGILE interface, observing and comparing how the participants interacted with the AGILE and a web browser-interface doing the same task. Number of errors and total elapsed time was collected. Participants were asked for their preference and informally invited to add any comment they considered relevant.

Based on the previous iteration with the MS PowerPoint prototype, an iteration of the AGILE interface was carried out. Therefore, the Goals' and Steps' Map were removed from the interface. The prototype was tested in a portable tablet device (iPad2) and it was implemented in iOS.

7.6.3.1 Evaluation process for comparison with other digital transaction

A post event evaluation was performed in order to refine the early prototype. The evaluation was carried out comparing the transaction in the AGILE interface versus another train ticket purchase in a rail website (see Fig. 43), using the same tablet device. Each user made two transactions, one on each different application, with a counterbalanced design.

The evaluation methodology worked toward evaluate quantitative results and refine the prototype adequately. First, the whole interaction process was recorded on a video camera, pointing to the tablet device to record user touch interaction. All the operations, questions and answers during and after the interaction were recorded. Second, some participants were eye tracked to facilitate the analysis of the performance with the tablet. After both transactions, participants were asked a qualitative questionnaire about their experience overall, particular issues and recommendations about both applications.

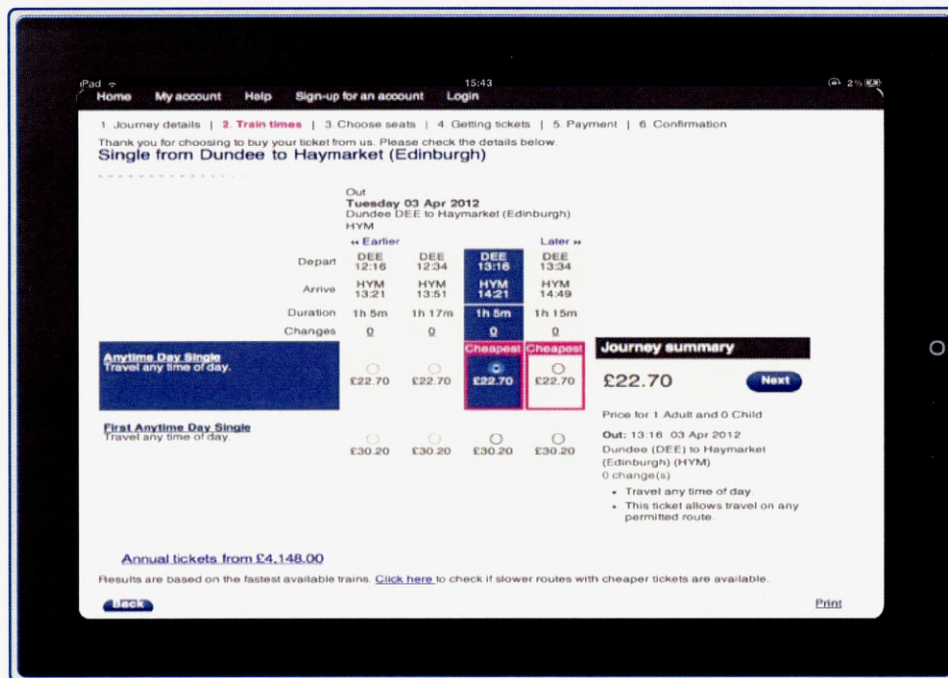


Figure 43. Screen capture of the rail website that participants had to use to buy a train ticket. In particular, when the user had to select the service time, type of ticket and price³¹. (Scotrail.co.uk)

³¹ All the screen captures of the task can be seen in Appendix XXIV.

This evaluation was carried out in Scotland (UK) at elderly users home and in Malaga (Spain), at a health centre and adult learning centre. In total, the number of participants tested was 11, 5 female and 6 male, with an age range between 58 and 83 years (average age in Scotland was 77 years, in Spain was 69 years, overall was 71 years) (see Table 21 to see participants' profiles). All participants did not have any disability described and had cognitive and physical impairments typical of those ages. All participants gave informed consent under the regulations of the School of Health and Social Sciences of the University of Abertay Dundee in English, translated into Spanish where necessary. To make the test more suitable, the absence of Spanish translation for the rail website led to the selection of another website, a common web store and the transaction changed to a book purchase (see Fig. 44). The adjustment of the AGILE version was done minimizing the differences with the AGILE version previously developed for the train ticket. This resulted in the same characteristic screens and tasks, but a reduction in the number of steps due to the book purchase transaction properties.

Table 21

Participant Profiles Iteration 2

| Partici pant | Ag e | Gen der | Nation ality | Assis t. | Self- reported Technol ogy Use |
|-------------------------|-----------------|--------------------|-------------------------|---|---|
| 1 | 81 | Male | Scottish | Glasses for short and long distance | TV/VCR/ Microwave |
| 2 | 83 | Female | Scottish | | Landline with dial |
| 3 | 77 | Male | Scottish | Glasses for short distance and hearing aid | Mobile Phone |
| 4 | 70 | Female | Scottish | | PC |
| 5 | 68 | Male | Spanish | Hearing aid | TV |
| 6 | 58 | Male | Spanish | | Landline with touchtone |
| 7 | 61 | Female | Spanish | Glasses for short distance | TV/VCR/ Microwave |
| 8 | 72 | Female | Spanish | | Smartphone |
| 9 | 76 | Female | Spanish | Glasses for short and long distance | TV/VCR/ Microwave |
| 10 | 74 | Male | Spanish | | Smartphone |
| 11 | 74 | Male | Spanish | | Mobile Phone |

| Partici pant | Ag e | Gen der | Nation ality | Assis t. | Self- reported Technol ogy Use |
|-----------------|---------|------------|-----------------|-------------|---|
|-----------------|---------|------------|-----------------|-------------|---|

Note. Assist. = Assistance



Figure 44. Screen capture of the website used for the book purchase transaction. In particular, when the book title had been found and the quantity had to be introduced (on the right side of the screen above the rectangular button “Añadir a la cesta”, in English “Add to the basket”).

Camera recording (Panasonic SDR-H85 with tripod) and eye movement recording (SMI Eye Tracking Glasses, 2012b: non-invasive video based glasses-type eye tracker, 30 Hz binocular, spatial resolution 0.1°, gaze position accuracy 0.5° over all distances, 3-point calibration, HD scene camera and audio recording) were undertaken during the test. All transactions were performed on the same tablet device (iPad2 with iOS

version 4.3.5 and the interface designed using Objective-C language in XCODE 4.2, SDK 5.0), in a controlled room with an absence of noise, disturbance and any other potential disruptions. Instructions of the transactions were the same (distinguishing between train ticket and book purchase layout and data, respectively) and provided in a sheet of paper³², constantly visible for the participant in all trials. AGILE interface versus rail/book buying website tests were counterbalanced across participants.

7.6.4 Results of the user test of train ticket transaction on rail website on iPad2

Analysis of the camera recordings showed that the transaction time was almost double on the rail website (an average of 6.5 minutes (SD = 0.68) compared with an average of 3.3 minutes (SD = 0.2) in the AGILE interface). The Time taken to conduct the train ticket transaction for Web Browser and for AGILE is presented by participant in Table 22, and the Average Transaction times are plotted in Fig. 45. Comparatively, the number of comments and assistance provided by the human helper was four times more than the one provide using the AGILE prototype. Furthermore, the content of the assistance was more loaded on the rail website, while in the AGILE comments were merely short confirmations or reminders to follow the instructions provided.

³² See Appendix XXIII for the list of instructions provided to participants.

Table 22
Comparison Train ticket Web browser versus AGILE transaction in iteration 2

| Participa nt | Web Browser Train Ticket | | AGILE Train Ticket | |
|------------------|-----------------------------|------------------------------------|--------------------------|---------------------------------------|
| | Trans. Time (sec.) | N. Errors / Human Assist. | Trans. Time (sec.) | N. of Errors / Human Assist. |
| 1 | 428 | 5 | 212 | 2 |
| 2 | 501 | 6 | 201 | 1 |
| 3 | 389 | 6 | 225 | 3 |
| 4 | 338 | 4 | 203 | 1 |
| 5 | 448 | 7 | 209 | 1 |
| 6 | 398 | 5 | 211 | 3 |
| 7 | 354 | 6 | 219 | 2 |
| 8 | 345 | 8 | 187 | 2 |
| 9 | 389 | 5 | 219 | 1 |
| 10 | 402 | 7 | 220 | 0 |
| 11 | 298 | 8 | 204 | 1 |
| Average +(SE) | 390 (12.5) | 6.1 (0.3) | 210 (2.5) | 1.5 (0.2) |

Note. Trans. = Transaction; sec = seconds; Assist. = Assistance; N. = Number

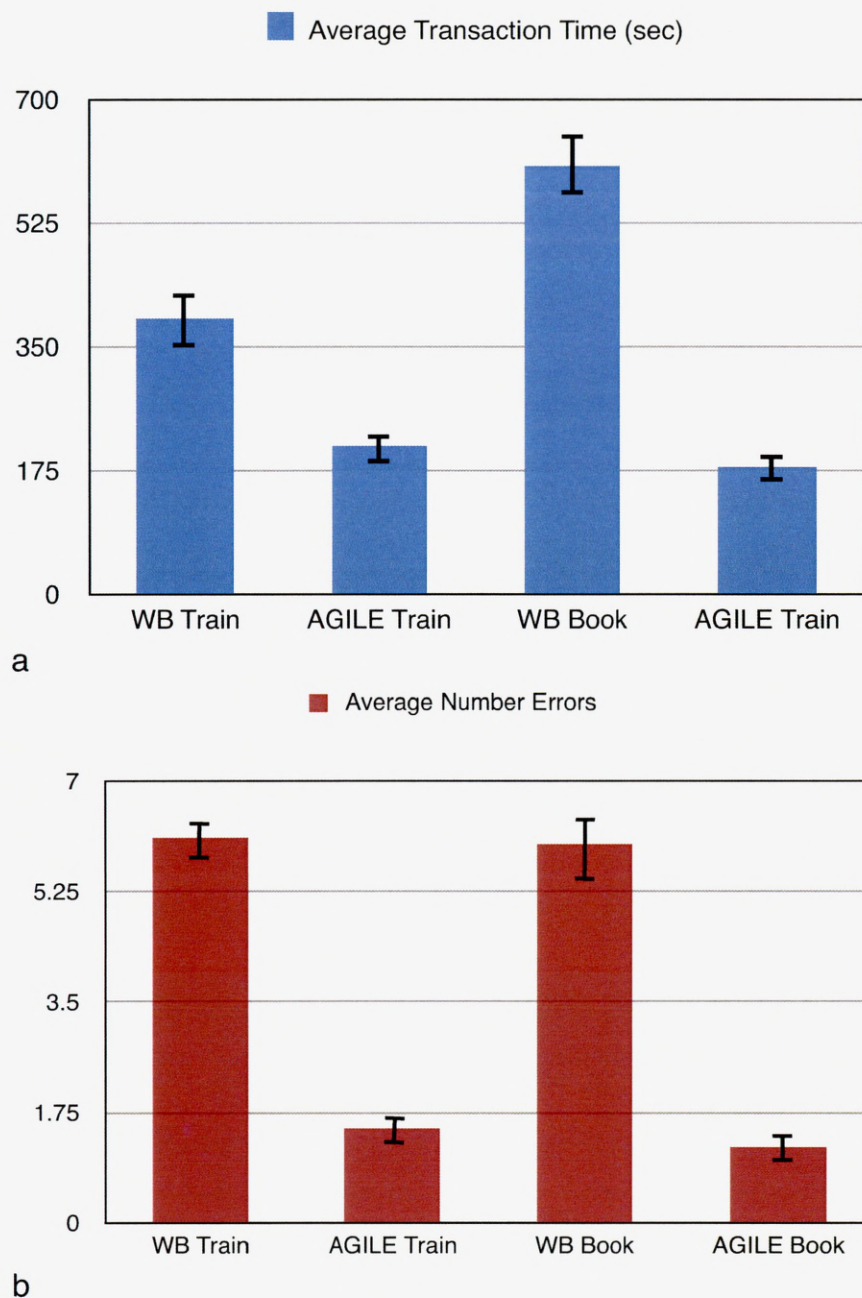


Figure 45. (a) Upper panel shows Mean Transaction Times for each Interaction Software Condition, error bars indicate ± 1 S.E. bLower Panel indicates Mean Errors for each interaction condition, error bars indicate ± 1 S.E.

In addition to this quantitative difference, other findings were based on the comments participants made describing the problems the users faced during the use of the rail website see Table 23). Mainly, problems were found in how to use the controls for inserting text (some participants missed the physical

keyboard and it took them some time to realize there was the possibility to have one displayed on the screen when a text box was selected), for selecting time and dates (very little space for their fingers) and how to scroll down or up the page to find the button to carry out the next step on the transaction. In addition, there was a screen where the button to go to the next step was not initially displayed and it only appeared when a train service was selected, increasing the confusion of *what to do next* in that specific step.

Table 23

***Participants comments from comparison
between Train Ticket Web browser versus
AGILE transaction in iteration 2***

| Partici pant | Type of Transaction | Comment |
|-----------------|-----------------------------|--|
| A | Train Ticket Web Browser | <i>"Too many buttons. I do not understand computers"</i> |
| A | AGILE Train Ticket | <i>"It is easy, it has less buttons"</i> |
| B | Train Ticket Web Browser | <i>"I do not know how to go backwards"</i> |
| B | AGILE Train Ticket | <i>"It is easier"</i> |
| C | Train Ticket Web Browser | <i>"What did you say I have to do, scroll down? How do I scroll down?"</i> |
| C | AGILE Train Ticket | <i>"It is very tidy. Difficult to do it wrong"</i> |
| D | Train Ticket Web Browser | <i>"I cannot select the correct date in the calendar, it is so tiny"</i> |

***Participants comments from comparison
between Train Ticket Web browser versus
AGILE transaction in iteration 2***

| Partici pant | Type of Transaction | Comment |
|-------------------------|--------------------------------|---|
| D | AGILE Train Ticket | <i>"The calendar is so easy. Why they do not use this calendar in the other program?"</i> |

7.6.5 Results of the User Test of Book Purchase on Website on iPad2

Similar results were obtained from the book purchase test transaction using a book buying website in Spanish. Although there were only three screens to go through, the time elapsed was again so much longer (an average of 10.1 minutes (SD = 1) compared with an average of 3 minutes (SD = 0.2) in the AGILE interface). The Time taken to conduct the book purchase transaction for Web Browser and for AGILE is presented by participant in Table 24, and the Average Transaction times are plotted above previously in Fig. 45.

The complaints (see Table 25) were about the amount of information displayed on the interface, overloaded with too many unnecessary elements irrelevant for the task in course. This issue together with the publicity appeared in the website conformed major distractions for participants. They argued that they had to spend much time reading messages and inspecting elements, with the high risk of selecting them and navigate to undesired screens. Additionally, only one participant could find the search bar without help. The rest of the participants had to be guided by the researcher to

successfully search for the title of the book. Even then, human assistance was some times required to finish the transaction.

Table 24

Comparison Book Purchase Web browser versus AGILE transaction in iteration 2

| Participant | Web Browser Book Purchase | | AGILE Book Purchase | |
|---------------|---------------------------|-------------------|---------------------|----------------------|
| | Trans. Time (sec) | N. Errors / Human | Trans. Time (sec) | N. of Errors / Human |
| 1 | 498 | 6 | 201 | 1 |
| 2 | 574 | 4 | 199 | 3 |
| 3 | 587 | 5 | 207 | 1 |
| 4 | 590 | 3 | 176 | 0 |
| 5 | 598 | 5 | 159 | 1 |
| 6 | 590 | 9 | 167 | 0 |
| 7 | 620 | 8 | 180 | 1 |
| 8 | 539 | 6 | 188 | 2 |
| 9 | 724 | 7 | 164 | 2 |
| 10 | 806 | 8 | 177 | 1 |
| 11 | 540 | 3 | 162 | 1 |
| Average+ (SD) | 606 (5.8) | 5.8 (0.5) | 180 (1.2) | 1.2 (0.2) |

Note. Trans. = Transaction; sec = seconds; Assist. = Assistance; N. = Number

Table 25

***Participants comments from comparison
between Train Ticket Web browser versus
AGILE transaction in iteration 2***

| Participant | Type of Transaction | Comment |
|--------------------|------------------------------|--|
| E | Book Purchase Web Browser | <i>"It has too many letters, names and things I do not know"</i> |
| E | AGILE Book Purchase | <i>"It is clear, organised, understandable. No complex instructions"</i> |
| F | Book Purchase Web Browser | <i>"The elements are too small to be seen or touched. I do not know how to go backwards"</i> |
| F | AGILE Book Purchase | <i>"It is easy. The 'Assisstant' is useful because it tells you what to do when I did not know it"</i> |
| G | Book Purchase Web Browser | <i>"I could not have done it without guidance"</i> |
| G | AGILE Book Purchase | <i>"it is easy because it guides you"</i> |
| H | Book Purchase Web Browser | <i>" Too much publicity but they do not tell me how do I go backwards"</i> |
| H | AGILE Book Purchase | <i>"Easy, straight and simple"</i> |

7.6.6 Discussion

Two AGILE type interface prototypes for mobile interaction were developed and iterated. Target end-users were novice elderly users, categorised as OU. Compared with equivalent web interfaces, both interface versions resulted in faster transaction time (an average of 3-4 times) and

best subjective preference (all participants chose the AGILE interface over the web based). The overall feedback and comments from participants were informative and useful for the second iteration of the interface prototype. However, more iterations are considered necessary to refine the design. In particular, metaphors for clock or item counter dials were difficult for some users based on assumptions about the functionality of arrow buttons.

The evaluation of the AGILE prototype (see Fig. 42), brought different and relevant findings. The early prototype showed how the Goals' Map is irrelevant for users when they face an unknown interface during a digital transaction. At first glance, it seemed to be relevant for the user to know where they are in the transaction flow. However, when there are too many new elements on the screen, that knowledge does not seem to be a priority for the users, making the elements to become distractive. Furthermore, showing the Goals' Map seem to be completely irrelevant for the current operation the user is performing.



Figure 46. Screen capture of the step 6, Seat Features or Default choice, of the second iteration of the prototype of AGILE interface for the train ticket transaction, shown in an iPad2. Note the absence of Goals and Steps' maps. There still remains the virtual agent (Assistance area) and the region with buttons (Interactive area).

A similar situation occurs with the Steps' Map. In the first iteration, many users were distracted with the steps, and semantically, they did not bring any useful meaning for the current operation. It was a distraction more than a help. This early prototype gave the opportunity to refine the interface for the next iteration, removing the Goals' and Steps' maps from the interface on the next UID iteration. In the evaluations of transactions on the tablet device, the comparison with a website where to do a mostly equivalent train ticket or book purchase transaction was very helpful. The problem of small screen space or using controls can be partially solved whether the website

implements the best controls available for such operations, such as the ones that Apple Corporation provides for time and dates (scroll wheels) on iOS devices. However, how to use these controls are not universally known for every user who faces the interface, for example, novice elderly users. Such is the case, that when participants were asked whether they knew the existence of accessibility features such as the 'Zoom in' or 'Zoom out' using two fingers to do the pinch gesture on the screen, they were surprised and argued that

"I was not born knowing that, nobody taught it to me. Now it is too late"

The concept of the VA is to overcome this problem by guiding the user in each step. In the prototype shown the VA is explaining with a polite written message the instructions in every step. Despite the increase of number of steps, the AGILE interface was preferred (from seven compulsory in the retailer interface to fourteen in AGILE's) (see Fig. 47).

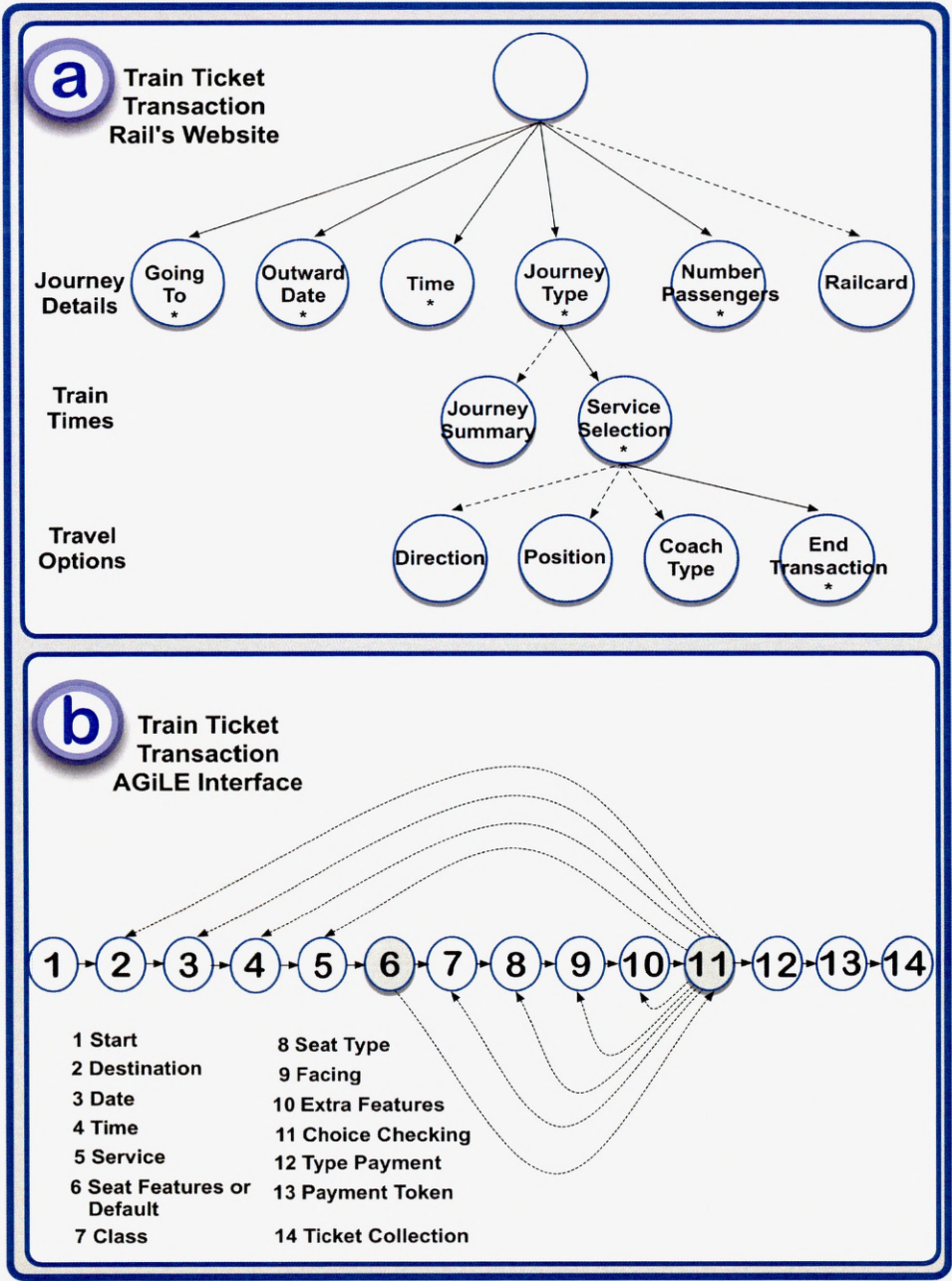


Figure 47. Task tree comparison of the analysed train ticket digital transaction. (a) Task Tree representing the tasks in the rail website with 12 tasks: 7 compulsory (*) with 5 with default values, and 5 optional. (b) Task tree of the same digital transaction in the AGILE interface with 14 tasks of which 14 were compulsory and none with default value. Note the possibility to go forward on step 6 (see Fig. 48) and backwards on step 11.

It seemed that the general approach and simplicity of the decision-making in particular have had a positive direct influence in the user satisfaction. In addition, the way that users could save time (step 6: alternative of directly going to last screen if user was in a hurry, automatically setting up the most common values on all the subsequent screens, as seen in Fig. 46) and amend decisions made (step 11: double checking of all the decisions made with the possibility of amending any of them if desired, see Fig. 48), were learned and used intuitively with no much effort. The equivalent undone step in the browser application was the backward arrow incorporated by default.



Figure 48. Screen capture of the step 11, Choice Checking, of the the second iteration of the prototype of AGILE interface for the train ticket transaction, shown in an iPad2. The user could see and change in one step the choices of the train ticket.

Despite the overall positive preference on the AGILE version of the interface (11 participants preferred the AGILE version, 0 the other), some

critical reflections must be mentioned about AGILE interface. First, the AGILE version did not have a text input option. Instead, the search was predefined and elements showed were already known (*Destination City* in the train ticket and *Book Title* in the book purchase). Second, there was a step in the AGILE interface that distinctly took more time for participants to perform and learn how to interact. It was the clock in the train ticket application or counter of number of same items in the book purchase application (see Fig. 49).



Figure 49. Screen capture of the step 4, Time to Travel choice, of the second iteration of the prototype of AGILE interface for the train ticket transaction, shown in an iPad2.

Some participants were 'stuck' until they found how to change the value, which was deliberately set up on zero. At the beginning, the researcher thought that the problem came from the digital numbers, which could be improved using other type of numbers. However, eyetracker (SensoMotric

Instruments, 2012b) data showed that for instance one participant was stuck in that step, looking to the numbers, then looked at the speech bubble and the agent, and back to the numbers again. It was a clear cycle of not knowing *what to do next*. In the Fig.50.a it can be seen on the left hand side how, starting on the number of items, the gaze travels to the speech bubble and agent. Few seconds of the recording show a cycle switching between counter of items and speech bubble and agent, with very few lines directed to the 'OK' button - Fig. 50.b. Instead of touching the 'up' and 'down' arrows, the participant touched the numbers trying to increase the number of items. Without a doubt, the lack of information to show the participant how to operate the control is a design error.

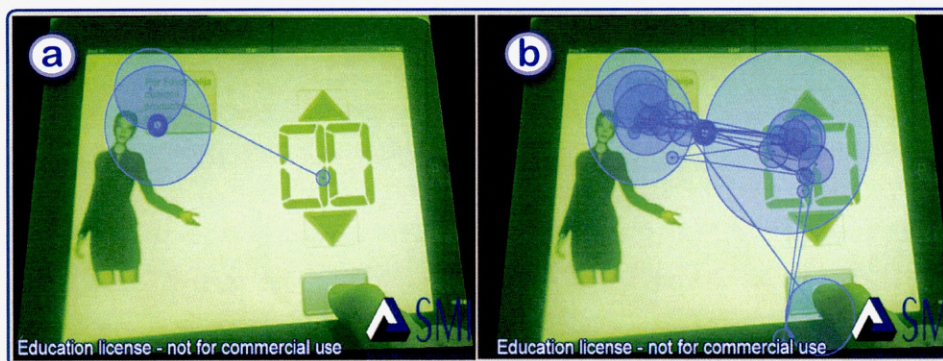


Figure 50. Detail of the scanpath of the AGILE interface of a book purchase. In particular, the number of books to be purchased (Spanish equivalent version to the step in the English version, Time to Travel, Fig. 49). The line represents the scanpath of the participant (74-years old), this is, the trajectory the participant's gaze draws on the scene recording. The circles represent the fixations of the participant, and the size of such circles means the fixation duration. (a) Beginning of the scanpath footage, with user's gaze traveling from counter to agent speech bubble. (b) Multiple fixations and trips between the counter, agent and speech bubble.

The participant touched the numbers trying to change their value, and for a long time after they did not realize that the green triangles above and below the numbers increased and decreased the value respectively. In addition, the most pressed arrow was the bottom one, probably due to its proximity to the 'OK' button. Another issue with the arrows was that some users simply pressed or held their finger down on the arrow waiting to see the value increased automatically when the button was held down. That option was deliberately discarded on the design process, thinking that maybe it was found only in recent technology and thus too advanced for novice elderly users. However, the comments brought the reason for such behaviour: some videocassette recorders and microwaves counters have the option of keeping the button hold to increase the value automatically and faster, as so do many digital alarm clocks. All these differences would have influence user preferences.

It could be argued that rather than using a website run on a tablet, the test should have run a specific mobile versions of the same website, which would potentially change its layout depending on device and screen resolution used. Perhaps this would have increased the performance and suitability of such application on portable devices. However, many retail and transport companies do not have separate applications, and many first time users may not seek to download specific apps even if they are available. Thus, it is argued that the comparison is fair for the following reasons. In the case of a specific application developed for mobile platform, the differences would be on the suitability of controls and maybe some differences in the number and size of the elements shown. In that hypothetical situation, it would still be far

from optimal because the main problems found will remain. There will still be a lack of knowledge on the users of how to use such controls, such as the accessibility features which are normally unknown for many first-time users. Controls, such as scrolling wheels for time and date, or pinch gesture to zoom in and out, are routinely used by most of users but unknown by novice users. In this case, user performance would increase in line with their intuition. Thus, the necessity of assistance, clear explanations and concise messages are essential for the correct use of the interface for OUs, and particularly for those with no technological experience. These problems were tackled in the second iteration of the AGILE interface. The VA expressed a polite and clear message in the speech bubble and pointed to the relevant area where interaction should occur. The size of the buttons, *Look and Feel* of the interface and the reduced number of options for selection (2 options in most of the cases, 4 options in two cases and only once with 8 options; not counting the calendar where technically the number of options would be around 30 depending of the month - but only one date is required), are also part of the approach.

To overcome these issues and generally improve the performance, a third iteration would introduce animation on the VA and its extremities, an 'on-the-fly' quick tutorial for explaining the use of complex controls. In tablet devices, an 'incorrect' tap of the numbers rather than the increment or decrement should generate an advisory message politely suggesting that the arrows can be used to dial up the required number. In addition, a deliberate order on the sequence of interface's elements presentation should be introduced: at start of each step, the agent should appear followed by its speech bubble, and

finally, the elements on the interactive area should appear. Thus, the prominence of the agent and the message with instructions would be increased. Finally, the use of sound designed to support the interaction would be carefully introduced.

7.7 Conclusions and Future Work

The case study provided a series of valuable insights into the designing of digital interfaces for OUs. First, in specific steps of the AGILE transaction (step 3 in book purchase to introduce the quantity of books; step 4 in train ticket purchase to introduce the desired departure time), the buttons were not seen. The user assumed that it was necessary to press the numbers instead of the arrows to increase or decrease the number (of books or time). When the numbers did not change, users then looked at the VA expecting some information or aid. Even if the buttons were successfully designed, this argues that the VA should be context-sensitive, reacting to erroneous user choices, for example by helping when repeated touches are made in an incorrect area. In this case, the VA should have communicated the user to 'press the arrows not the numbers'. Only one trial from one participant was needed to find this problem. The argument for this approach is that to quickly generate an insight in a design, it is not always necessary to run a hypothesis driven fully controlled series of experiments. Rather a methodological approach, consistent with the case study presented, would provide valuable insights into how the participants interacted with the prototype. Repeating this process over the output of successive iterations would refine the process until the designer can reach acceptable levels of

user satisfaction and experience. The decisions about the level of evidence required in the design of mobile interface design iteration are, in the commercial world, a balance between the competing demands of the overall budget for the application, the scope of the application, the proximity in time of potential rival applications and so on. In the commercial world of software development, many applications are launched before they are perhaps fully ready (i.e., Alpha and Beta versions), however an iterative design cycle with formal constraints should accelerate the error trapping process.

The second insight came from a participant who said: “This is all very good but I could just go to *El Corte Inglés* [a large department store downtown]”. This highlighted the problem with usability discipline when conducted on campus or in a business environment. The social context of the experiment tends to oblige the participant to complete the transaction since they entered the room with the unique goal of completing the transaction. In real life, if other options are available, the user (shopper, traveller or customer) could find a different alternative in other place with equivalent service according to their needs. For example, Frei (2006) provided evidence describing the case of the retail Bank First Union in the late 1990s that misdiagnosed customer needs. After creating many SSTs for customers (primarily through ATMs, voice response units and web pages), First Union hoped that the cost of the innovations would be more than regained by lower costs in branch operations. After limited success, management efforts were made introducing a ‘greeter’ at the door of the branches to ask about their customers specific business nature and recommending using the ATMs to

accomplish their transactions. Within months of the intervention, 20% of the most recent accounts were lost.

The cause for the loss was not hard to trace: It came down to a misunderstanding of why the self-service options had not caught on among all customers. The variability that was actually at issue was not capability variability but effort variability. Customers with time on their hands preferred to wait in line to have the teller do all the work.

Acting on untested hypotheses is a common mistake when the logic of what is (presumably) good for customers is widely accepted. First Union reasoned that if customers only knew how much better off they would be using ATMs, they would surely choose to serve themselves. Had the bank tested this assumption—by, say, asking customers why they used particular channels and what they thought of alternative channels—it would have exposed the flaws in its thinking (Frei, 2006, p. 9).

This chapter has described a new interaction style specifically addressed for OU, whose intrinsic characteristics make it necessary to tailor a specific interaction style and UID adapted to their needs. Without asserting what sort of approach is better for HCI interface design ((1) designing for one uniform user group; (2) designing different interfaces for different user groups; (3) designing an adaptive interface (Aykin & Aykin, 1991)), the interface adaptation has been incorporated in the design stage.

The user and their needs have been placed as an essential component of UID, shaping a new interaction style ideally conceived for users with no IT

experience nor time to learn. The AGILE interaction style, aimed to be adapted to the idiosyncrasy of a OU, in this case the novice elderly user. This type of user introduces some peculiarities, such as lack of motivation to learn and absence of effective memory recall, even in the same session, (exacerbated by the lack of didactical approach in many Graphical User Interfaces (GUIs)). This issue has been covered by the use of an effective guidance and assistance system for every step of the interaction process. The assistance has been implemented by a VA, in charge of guiding the user in the current goal achievement. Physical cues and gestures orient the user's attention to relevant areas of the interface to enhance interactivity. The simplicity of the interface layout becomes essential, as well as the effectiveness of the assistance and concise use of the metaphor.

Reducing the number of items on any one screen has the benefit of minimizing the risk of change blindness from the observer of the interface (e.g., Rensink, O'Regan, & Clark, 1997). Even simultaneously presented items can be difficult to segment and parse appropriately when there are too many items (Scott-Brown, Baker, Orbach, 2000). By minimizing comparisons and items, decisions and detections have been maximally facilitated. For instance, to enhance touch (Stevens, 1992) and visual experience, clear and large sized icons have been selected, accompanied by text descriptions (as recommended in ISO 9241-171, 2008).

This work has carried out transnational novice elderly user testing using touch interface on tablet devices, with video camera recording, eye tracking recording where possible, and questionnaires. The evaluation process has brought helpful findings such as the suitability of the AGILE interface for

occasional digital transactions, with the examples of buying a train ticket or purchasing a book. The style presented has been evaluated on the target users, the novice elderly. Among the most valuable features demonstrating their suitability are simplicity and clarity, guidance and error-minimization that the AGILE interface presented during the whole interaction process. *Simplicity* in the effortless decision-making exhibited in each step, with a minimum cognitive load attached. *Clarity* in the display of only indispensable elements necessary to accomplish a transaction, with large buttons, legible font and overall concise messages. *Guidance* in the succinct instructions given by an agent in each step, placed in a wide and visible region inside the interaction area. *Error-minimization* by restricting the possible options user has in each step, without affecting the effectiveness of the goal accomplishment and therefore satisfaction involved. All these features could be adapted in the design process, whether the target user group varies, for instance, maximizing the use of the sound channel for a blind user, or the assistance method to show how to do a gesture in the case of not knowing it, etc. However, these revisions of the interface should always be part of the design process, carefully tested and iterated. It is the ultimate goal of this AGILE approach, to present a consistent interface among users with no technology experience, lessening unpredicted changes during use to maximize stability and productivity of the interface.

A third iteration of the interface would be needed to avoid problems on design and effectiveness, with certain elements such as the clock/counter and the increase operation associated. Animations of the VA, quick tutorials

of such controls and order of the sequence of elements revealed are to be included in it.

This work is part of a new approach on UID, where user 'inexperience' is assisted with a deictic guidance linked to the narrative of the interaction. Further development will explore different types of tasks, widening in variety and complexity to present new challenges for designers, modifying or updating any of the principles exposed here. Finally, testing the interaction paradigm with users with other cognitive limitations, such as dementia or Parkinson's, and finding exemplary interactive elements for their interface is priority.

7.8 Reflective statement

The research experience gathered through the experimental design presented in this thesis, formed by 6 experiments, and the case study, gave the author a valuable understanding of the trade-off between scientific experimentation and the satisfactory design of user-experience (UX).

In the experimental stage, there were several reasons for the inclusion of the VA: to improve the search strategy, to shorten the selection RL and to test different virtues of a virtual human-like spatio-visual cue stimuli such as motion, emotion expression and the principles of animation. These three components were used in search of a better user-experience, rather than, solely, to create a faster interaction with the system. The use of motion was motivated by the relatively automatic human brain mechanisms able to detect motion (e.g., Regan, 2000, Blake and Sekuler, 2006; Goldstein, 2010) rather than the more cognitively driven recognition mechanisms required for

accurate spatial vision. The particular choice of agent animation over other forms of cues such as arrows, and the need for this to be animated was inspired by the way that biological motion stimulates the brain when viewed. Oram & Perrett (1994) showed how single cells in area Superior Temporal Sulcus (STS) of the macaque brain are particularly well tuned to point light walking stimuli compared to matched control motion patterns. Grossman and Blake (2001) replicated this effect in human observers.

In behavioural experiments with human observers, Shiffrar and Freyd (1990, 1993) showed how important the temporal sequence of frames of human motion animation can be towards authentic perception of motion. When presented with two alternating frames of a human agent with two different arm gestures, only delayed presentation with a plausible time difference that would make the animation of arm movement appear 'possible'. Rapid alternation, made it appear impossible. To emphasize how important this effect is, a follow up study (Stevens, Fonlupt, Shiffrar, & Decety, 2000) showed that the correct timing for the picture animation recorded not just activation in parietal cortex, but also specifically in the motor cortex. Thus, a correctly animated agent, with biologically plausible time intervals between cues has the potential to reach deeper neural structures than would be possible with other stimuli.

HCI represents action between a human and a computer system, and action is a synonym of motion. Therefore, in the interaction with a digital interface, reliance on movement as a principle for showing, demonstrating and orienting becomes plausible. Movement is normally used in other unfamiliar situations in interpersonal interactions, such as when arriving first-

time to a hotel and the receptionist gestures and speaks welcoming a guest; when attended by a restaurant receptionist, or 'maitre-de', when customers have just arrived to have dinner in a restaurant, etc. In the hospitality industry, there is a consensus (Blue & Harun,2003) of how to welcome guests: eye contact means being attentive and thus caring for the customers. It also indicates politeness (Livens and Brown (1987) termed *positive politeness* as the explicit attention to needs or wants). Verbal and non-verbal messages are conveyed and exchanged, and both host and guest conform to certain predictable behaviour, conventions, when addressing each other (adapted from Blue & Harun,2003). This so called *hospitality language* (Blue & Harun,2003) can be implemented in the context of a digital interface where the host-guest relationship is represented by an unfamiliar user and a human-like system (VA) respectively. From there the importance of a VA as a central component of a guidance system for unfamiliar user.

To further explore the potential reach of a guiding agent on a generic interaction interface, Emotion expressions were used to explore the influence in RL of negative and positive valence expression. However, the lack of context meant that the results were of limited use. The lesson being that emotion expressions may still reach their potential if they are presented in consonance with a context that requires a message with qualitative connotations, such as reminder, warning or avoidance of wrong actions.

Finally, the use of the principles of animation pursued the utilisation of the techniques developed by experts focused on the representation of features pleasant to the spectator eye. With it, a qualitative judgement was gathered and importantly, juxtaposed to RL as a unique measure. This finding

suggested that there are other factors, especially qualitative, that should be taken into consideration when designing interfaces for unfamiliar users and using VA as guidance system. Likeability, believability or suitability are components of the subjective interaction with another agent (i.e., virtual agent or human being) that influences the interaction development and outcome.

There is a substantial difference when comparing the experimental design with real-world scenarios. The participant's goal in the experiment was to select a correct button, whereas in a real-world scenarios, the transaction itself is usually a step towards the consecution of another goal. People usually conduct self-service transactions as a subgoal of a major goal: in the case when a person has to travel to a specific destination, the traveller needs to go to the station to take a train. To legally take that train, a ticket must be bought, for instance, at the self-service machine at the station. In the experiment, the goal is the task itself - with an absence of major goals. However, if it is an urgent journey, the goal of the passenger is to 'not miss the train'. At some point, they may 'balk' at the transaction, and jump aboard. This type of decision is not easily replicated in usability studies since they are currently conducted on campuses without heavy time pressure.

Thus, with a major goal in mind, a user (also traveler, customer or passenger) can be easily distracted by any element external to the transaction that is a priority for the consecution of that major goal (e.g., a traveller/customer in station about to catch the train but wanting to buy confectionery, with a SSCO might erroneously scan an item, but forget to put it on the scales, while they are distracted looking at the train times - after all

‘they do not need the bagging area, they are just buying one thing’). Therefore testing valid paradigms in the laboratory does not ensure their validity in real-world HCI, especially when complex human mechanisms are involved.

In this case, one of the underlying paradigms of the VA cues is the need to take on board the design of the dynamic characteristic of the interaction. If not, there is a potential risk of using proven paradigms in erroneous contexts, such as the use of salience models to analyse human eye behaviour in dynamic scene observation (Tatler *et al.*, 2011). The salience model is based on pictorial stimuli, so it takes into account what is seen in a static fashion, without a time component in the model. Therefore it does not incorporate the behaviour of the human eye, essentially task-driven and constantly involved in dynamic situations. There is a consonance between ‘A’ the characteristics of the scene observed: the visual properties and how they change (e.g., dynamic situation); and ‘B’ how these properties interrelate with the observer: the effects of the information retrieval for the task at hand (i.e., human eye behaviour); the hierarchy of goals (i.e., human mind functioning); and how the human eye behaves (e.g., preference for foveal information gathering versus peripheral information gathering).

With the above limitations in mind, the case study is led by an iterative design, fed by quasi-experimental cycles. The design cycle is informed by a specific profile of user, the Occasional User (OU). Often the need for the innovation in design is triggered by an identified problem. However, problems identified and solutions developed might still fall foul of the ‘untested hypothesis problem’ discussed earlier from Frei (2006). For example with a

commercial car park, the problem might be that 'people are not paying for their tickets'. So it might be that a company might adopt Automatic Number Plate Recognition (ANPR) to capture all data on visits, and remove the need for the parking attendant. The ANPR can associate customers with payment, all non payers can be traced and all traffic is registered. This solution theoretically would also reduce time an effort of customers paying for their parking time. However, if not properly thought through or signposted, problems can arise. If customers need to remember their car registration number to exit, then they might have to go back up to their vehicle to check, thus leaving the machine, mid transaction. If there are many cars with similar registrations, then the search time would also increase, if the transaction required identification of the photo of the registration plate from the camera feed. This solution could provoke queues that were not existent before and therefore increase or introduce frustration among the customers.

This is an example of poor user-experience and the business would suffer decreased revenue when the solution became more expensive than the problem intended to solve³³. This sorts of problems can ultimately be seen as representative of bad procurement, instead of a bad design. When the context of the problem is correctly defined, in a open way, there potentially are many OUs that are not going to learn how to use a system. Instead, they want to just simply achieve their immediate goal. When the design incorporates alternative methods considering the context and the user needs, solutions generally lead to better satisfaction (Martinez et al., 2012). These

³³ At the time of writing, such a system has been introduced and then subsequently withdrawn from a car park at a major Scottish metropolitan railway station.

designs of public space transactions have a direct impact in economic affairs, such as those related with Tourism, retail or banking. They can also underpin feelings of health and well-being, with marginalized user groups at risk of exclusion through inappropriate interaction modalities (e.g. a customer who cannot use an ATM becomes disenfranchised if their local bank branch is closed down).

The research presented in this thesis reflects a journey from scientific experimentation towards the design of UX for users unfamiliar with the interface. Some of the evidence has been collected through process of observation and the application of principles in a real-world scenario. Objectively measured user frustration has been shown to be a difficult enterprise in a controlled experiment (Martin *et al.*, 2013), where factors such as public space can play a determining factor in how users feel, express and perceive the environment. Following the Cognitive Ethology approach (Kingstone *et al.*, 2005), a UX design can be enhanced by a case study in the field that can provide an insight into how users prefer and feel when interacting with digital interfaces designed specifically for them (e.g., Martinez *et al.*, 2012).

Other insights were gathered from the experiments. For instance, the evolution of the appearance of the buttons was considered satisfactory by participants from the experiment 4 onwards, when they adopted a more realistic and usable appearance. Another insight was the one provided by the eye data recorded in the case study, by which a problem in one of the steps of the AGILE transaction (i.e., counter or clock) was detected. In conclusion, in order to get a design insight it may not have to be necessarily scientifically

proven (indeed some insights may not be 'provable', just as in logic, not all theorems are provable). A pure Psychology approach is appropriate to understand the phenomenon, but to engineer a solution there is a need to use creative insights. Ultimately this is a problem of empiricism and the scientific evidence required for the problem. For scientific explanations a higher standard of evidence is needed than the standard needed for justifying a design insight. Incompleteness theorem argues that not everything in Science is going to be provable (Hofstadter, 1979). In Design, it is not practical or efficient to 'prove' everything before commencing with an innovation, because some innovations can only be proved after they are made (e.g., by public responses to implementation). Scientific explanations need experiments, but innovations need insights, and not all insights come from experiments; some come from observation, practice-based approaches, or accumulated experience.

Chapter 8

Conclusions

8.1. Conceptual Underpinning of the Research

This thesis started with the elaboration of the hypothesis related with digital transactions for inexperienced users (Chapter 1). The hypothesis was the result of a process of observation of a real-world problem encountered on Self-Service Technology (SST) transactions, inspired by a world-wide leader SST designer company and contrasted with target end-users. The three main issues associated with that context of use that were addressed in this thesis are briefly described below.

8.1.1 Problems of unfamiliar Self-Service Technology transactions

SST transactions have inherently attached a problem related with the inexperience of a user performing unaccustomed tasks. Previously in a retail transaction the shop assistant was the gatekeeper operand of the transaction. Nowadays, in shops with SSTs, the customer then becomes the new gatekeeping operant. However, the shifts in the service operant that SST carries out do not implicitly transfer the tacit knowledge that an expert staff member professionally has, making the user/customer the new responsible actor for the interaction outcome. In addition, the changes presented in the SST digital interface can be easily undetectable by an unaware observer. This Change Blindness phenomenon has been observed in situations where observers were even advised of an incoming change during a specific interval of time on flickering images. Finally, the interaction with these machines tend to be occasional by nature of the SSTs, usually placed

outdoor and in public spaces. The idiosyncrasy of such use has consequences such as blurring the distinction between experts and novices and presenting new challenges for designing interfaces of one or occasional use.

8.1.1.1 Moving a task to an inexperienced user does not transfer expert's tacit knowledge

This research addresses a problem inspired by a digital transaction in a SST device where the user is unfamiliar with its interface and therefore its functioning. SST is becoming a substitute of the traditional way of doing transactions where the interface with the customer is the device itself, instead of a well-trained staff member to whom the customers (technology users) are used to and feel familiar with. The introduction of SST has several implications for the users, such as, for example, the specific tasks that were previously completed by trained members of the staff are now transferred to the user. This fact does not imply the transference of staff member's tacit knowledge (Meuter *et al.*, 2000), which results in the customers having to undertake unfamiliar complex tasks - e.g., each shopping transaction in a Self-Service Checkout (SSCO) goes through a complicated process of fraud prevention based on weight comparison of items in the bagging area - and becoming responsible for the transaction outcome. These issues are accentuated by the lack of identifiable immediate help sources that could show the user how to avoid such difficulties. In conclusion, SST's present representative challenges of digital interactions where the user is unfamiliar with the interface, and the sources of traditional help are unavailable. The

unprompted transference of responsibility for complex task accomplishment and transaction outcome are only two of the several factors that are implicitly assumed in this type of Human-Computer Interaction (HCI). Most users, especially first-timers, are unaware of how to accomplish these types of tasks and as a result their confidence is undermined (Frei, 2008).

8.1.1.2 Change Blindness makes user-interface elements undetectable

SST requires from the user a considerable attentional load to successfully accomplish their new physical and digital labour. An inexperienced user will see the User Interface (UI) as a set of new items without knowing with absolute certainty the order and type of actions required to accomplish the transaction. The amount of attention required by the UI will be in inverse relation with the experience the user has with that particular technology and their capability of noticing elements inside the interface. In this scenario, attention is necessary but not sufficient to let an observer to detect changes in an observed scene. Change Blindness (Simons, 1997; Rensink, O'Regan & Clark, 1997) as a topic provides helpful prism with which to view some of the problems of SST: in the absence of a transient visual cue (such as motion), or externally provided verbal prompt, changes in a complex visual scene are hard to detect. Normally as the interaction develops, new or more elements are introduced. Unless these elements are specifically indicated, they will be often ignored by the inability of user to detect changes, due to flickers or other blinks. This problem can be overcome with cues such as motion transients, flashes or verbal indicators.

8.1.1.3 Expert regress to novice when they are unique-time users

One of the most recurrent problems in HCI is when a user does not know what is the next step to go ahead with an interaction, the so called *what to do next* problem discussed in Chapter 2. This problem is dependent on a number of factors, such as user's skills, applied technology or User Interface Design (UID), and they are generally accentuated by the user's personal lack of experience in the system. This thesis aimed at the particular case of when the problem of *what to do next* is presented with regards to the user's inexperience with specific digital interfaces. In situations where users face an interface for the first time, there is not necessarily a large pool of previous experiences to draw on to help the user conclude the transaction. In these situations, there may be an implicit assumption on the part of the designer that with practice the user will learn the sequence required. However, for some users the likely number of future interactions may be very low or zero and so the developer's assumption may be overly optimistic at best. At worst, if the user experience is too severe, they may decide that the system 'is not for me'. In these situations, there is a strong case for assuring better interface learning at first use.

In addition, when the number of sessions of a user with an unfamiliar interface is restricted to one, there cannot be what has traditionally been called user levels, because even the most expert user might regress to novice in terms of knowing how to use an interface for the first-time. If this unfamiliar interface is of sporadic use such that future sessions with it cannot be completely assured in a sufficient number for the same user, the mechanisms to guide and lead the user to achieve their goals are more

necessary, but, at the same time, also more difficult to implement because they cannot rely on traditional recall-based strategies of a continuous learning through prospective sessions. In this case, the user should be considered as a first- and unique-time user.

8.1.2 Solutions addressed to the problems associated with users unfamiliar with digital interface in the context of Self-Service Technology transactions

The research presented in this thesis addressed the problem of a first-time user facing an unfamiliar interface. The research approach lies on three objectives (as seen in Chapter 1) to improve the computer mediated user experience. Firstly, an attention cueing paradigm was used to mechanically guide the human user to a successful item selection inside the digital interface. Secondly, the creation of a new category of user, the Occasional User (OU), met the requirements for an occasional use of an unfamiliar interface which has traditionally alienated user expertise. Thirdly, a new style of interaction, Assisted Guided Interaction with no Learning nor Experience required (AGILE), was addressed to the OU. AGILE was represented by an interface that does not require previous experience nor learning process to its satisfactory use. The outcome of this thesis was the result of the development of 6 experiments and 1 case-study with a transnational target-user testing.

8.1.2.1 Virtual agent spatial deictic cues

Human spatial attention has been used as a mechanism to recognize where an individual is looking when searching for something (i.e., when the mechanism of attention is coupled with the mechanism of eye movements), with the utility of directing user to specific areas of a UI. It can be used as a two-way process that while it allows to direct user attention to interface elements, it also informs how the user scrutinizes such interface. Thus, human spatial attention is critical in the design to detect what parts of the interface are inspected and which are ignored, becoming a necessary component to be evaluated for the success of interface guidance mechanisms. Only by knowing first how attention works, is it possible to apply human attention paradigms in UID, implementing methods of directing user's focus in an effective and believable way.

Spatial attentional cues have a function of orienting in the space. These cues can be used for instance to indicate sequence of actions, distance and positions relative to the observer. When these cues are performed placing the observer (i.e., technology user) as the centre of origin, spatial cues have the potential to indicate information of observer's world. This research has used gaze and head spatial cues implemented by a virtual agent (VA) in a series of six experiments to test the viability of these Psychology paradigms in a HCI context. The first evaluation has included VA static spatial cues to guide in the search of a target item in the context of a digital interface. It has been demonstrated that correct target selection among an array of homogeneous potential targets (identical buttons only differentiated by text label) are faster when comparing with no visual aid (Experiment 1). The

analysis of the conditions of visual aid resulted in a significantly lower number of targets visited which consequently reduced the number of fixations (Experiment 1). Following this, the type of motion in visual cues was tested, comparing static, 2-frame and dynamic VA spatial gaze and head cues. Dynamic cues presented faster response latency (RL) both in gaze (Experiment 2) and touch (Experiment 3) modality of response, ranking the more dynamic and natural way of cueing as the best option to increase the speed in correct target selection.

Emotion expression is an important component in social information communication because it acts as a mechanism of adaptation to environmental stimuli and as a manifestation of affective states. This adaptation and expressivity could theoretically have a potential usefulness in a digital interface implemented on a VA. The introduction of emotion (of positive and negative valence) in the VA did not incorporate any benefit in RLs compared with a neutral expression (Experiment 4). Emotion viewing triggered an attribution of an artificial intelligence to the VA by the majority of observers, arguing that would have justified VA mood changes (changes in the expressed emotion across trials).

Finally, the last evaluation assessed the efficacy of VA spatial cues performed using the principles of animation. For over seventy-five years, animators have been trained to predict viewer eye movements. Their tacit knowledge acquired throughout a continuous practice-based approach culminated in a series of principles to develop animations aesthetically engaging for the audience. Therefore principles of animation could potentially be used in the developing of spatial cues to enhance user attention allocation

and item selection. In addition, a measure of likeability was introduced in order to compare response speed with subjective judgements of likeness. The results showed an inverse correlation between the speed in the response and the Likeability (Experiment 5 and 6). The fastest responses were obtained to the VA's cues developed with the absence of animation principles, while the most likeable VAs were those with the application of animation principles, especially those showing non-linear behaviour. These findings suggest that a combination of objective (e.g., Response Latency) and subjective measurements (e.g., Likeability) into research design and analysis are necessary to holistically evaluate a human-agent interaction in the context of digital interfaces.

8.1.2.2 Specification of the Occasional User

The target user of this thesis belongs to a new category of user not specifically nor exhaustively described in the literature: the Occasional User (OU). Examples of this type of user taken from the real world include heterogeneous interaction SST contexts with an unfamiliar interface, such as to complete a self-passport authentication during a vacation, or once-in-a-lifetime trip.

Traditional user classifications have relied on user technology expertise ascribing their interface knowledge to certain level of familiarity with the system in particular, or analogue systems in general. However, the occasional use of an unfamiliar interface is a case where the user's expertise is not the most important factor to take into account in UID. This is so because the user's unfamiliarity with the interface limits the user's prediction

or knowledge about how the interface would work. The lack of a sufficient number of sessions with the interface impedes the reliance on traditional learning mechanisms of repetition and recalling, making the OU a distinctive user compared with those commonly accepted user classifications (e.g., Shneiderman, 2005). Such use should be labelled as the first- and unique-time use. This is what is called occasional use (Chapter 2).

An OU has defined characteristics such as the specificity of goals they want to achieve, the unfamiliarity with the interface, and the lack of previous experience with the particular interface or any other analogous one. The time to learn how to use the interface is limited to the session under way, with no expectation of repeating the use of the interface in the near future. All these features result in very specific demands from the UID and its functionality, introducing great limitations to learning mechanisms of repetition and functionality recalling (Chapter 2).

8.1.2.3 Interaction style for the OU

The intrinsic characteristics of the OU require a new *ad hoc* interaction style design adapted to their needs, named AGILE. By applying User-Centre Design (UCD) principles, the design of the UI centres on the concept of users without experience in the studied digital interface, and without time or capacity to learn how to use it. For it, novice elderly users were selected as target end-users to test and evaluate a UID based on AGILE.

The AGILE interface incorporated an effective guidance mechanism in each step of the interaction, represented by a VA with physical cues and gestures to orient user's attention to relevant areas of the interface. Additionally, the decision-making steps have been simplified in order to

reduce the inherent cognitive load of each choice. This simplification was carried out as a part of the error-minimizing strategy that aims to increase user satisfaction and reduce user frustration.

A transnational evaluation with target end-user testing was carried out. Results showed that despite the fact that the total number of steps of the AGILE interface to accomplish the transaction was substantially increased compared with the base line, this type of interface drastically reduced the total transaction time and increased the overall user satisfaction (Chapter 7). These findings were examples of an interaction style whose interface presents a consistent design across users without technology experience, lessening unpredicted changes during its use to maximize user's performance and reduce their frustration (Chapter 7).

8.2 Innovations arising from this Thesis methodology

There are four main innovations that the methodology of this thesis has brought. Firstly, the stimuli used in the experiments have incorporated a dynamic element of motion. In contrast with most of the stimuli used in Psychological studies (e.g., Kuhn *et al.*, 2009), it has been used a natural way of directing observer attention. Secondly, the validation and use of a gaze induced cognitive response that allowed to detect the positive effect of VA deictic cues. Thirdly, the employment of an artistically animated human-like VA to ideally represent gaze cues and be easily recognized by a human observer. Fourthly, the rise in the ecological validity of the research, testing several paradigms validated in the laboratory with the end-users on a mobile platform in the field.

8.2.1 The importance of the Stimuli

The importance of the stimuli used in the experiments presented in this thesis resides in its innovative way of creating them and the homogeneity of targets' appearance.

The process of stimuli creation is especially relevant to the animation of the VA used in the experiments. The use of a 25-image per second dynamic stimuli contrasts with the static or 2-framed stimuli most commonly used in Psychology research of attentional spatial cues (e.g., Kuhn *et al.*, 2009). Using a 25-image per second VA represents a dynamic and natural way of orienting user attention to guide in the successful selection of a target item inside a digital interface, employing cues in line with those observed in social context.

The homogeneity of target appearance has been maximized in order to avoid the *set-size effect* (Palmer, 1994) as a potential contaminating factor in the analysis. Making targets equal in appearance was a way that positively contributed to reducing the discriminability between them. The spatial cue paradigm used a homogeneous type of targets, with an equidistant distribution in relation to the centre of the screen (and VA) and between themselves in a clock shape distribution. The stimulus was identically built across experiments, varying only in the conditions analysed (e.g., motion, emotion, animation principles). Setting up the homogeneity of the stimulus and targets allowed the investigator to analyse the search strategies with the sensory contributions controlled.

8.2.2 Gaze induced cognitive response

The small scale in which human spatial cue paradigm operates (milliseconds) lead to use a gaze response mechanism as the participant input in the Experiment 2. It implied a challenge of establishing the threshold above which a persistent gaze on a target is considered a conscious response to the task. In the light of previous literature, a full gaze fixation duration criterion for an observer response varied in a range of 400ms (Ware & Mikaelian, 1987) and 150ms (Sibert & Jacob, 2000). Thus, because extended forced fixation ($> 400\text{ms}$) can become laborious, a criterion for successful cognitive response to fixation was established as equal as or greater than to 250ms (i.e., a fixation that locates a target area at least during 250ms). This criterion successfully enabled the post-event eye movement recording to detect the first fixation inside the target and the interpretation of a cognitive response, comparing the RL across the different conditions studied in the Experiment 2 (Chapter 5).

8.2.3 Artistically animated virtual agent for guiding, helping and humanizing the transaction

The VA has been employed as the vehicle to implement the attention direction mechanisms performing spatial visual cues. A shape of a human VA was chosen: first, to represent human gaze, and second, for the human characteristic that would make the agent recognizable by a human observer. The performance of visuo-spatial cues has been made using the principles of animation (Experiment 5 and 6, Chapter 6), and pursuing an aesthetic

engagement to substitute a frequently reported robotic awareness that could cause a suspension of disbelief and invalidate the VA's purpose.

The discipline of Animation is therefore one of the essential steps in UID that incorporates a dynamic VA with naturalistic behaviour. It imbues the agent with living authentic features, such as motion. Motion is understood as a result of the essential synchronicity of movements in VA eyes, face and head, rather than a linear translation between spatial points 'A' and 'B'. This harmony in motion performance is artistically achieved by virtue of the principles of animation that make the VA behaviour believable and aesthetically engaging. In summary, it resembles the natural deictic gestures and cues observed in human conversations, connected with the natural experience of the human user, who is used to see and use motional cues on a daily basis in interactions with other humans.

8.2.4 Inclusion of ecological validity

The cognisance of ecological validity was of paramount importance to this thesis. It explains: the categorisation of the target end-user, the OU; the creation of an interaction style specifically designed for that OU, AGILE; and the utility of the findings from Attentional Psychology paradigms which were translated from the laboratory to real-world scenario.

Another influential factor was the use of two different modalities for participant input response, i.e., gaze and touch. The use of dynamic stimuli searched the naturalness and similarity of the task to those commonly found in real-life situations (e.g., find next button to push). The implementation of visuo-spatial cues was made in a range that went from the absence (static and 2-frame cues) to a full application of motion (dynamic stimuli) using the

principles of animation (5 animation principles applied and combined altogether). The application of those principles demonstrated the relevance of the synchrony of movements of the different components of a whole piece (gaze, face and head) to building an effective and believable spatial cue in-motion.

In summary, decreasing the barriers that the unfamiliar first-time use carries out, the aim was to recover for a digital interface user the quality of the familiarity of what is quotidian.

8.3 Future Work

8.3.1 The world outside the interface is inside user's frame of reference

A potential application of the demonstrated cue paradigms implemented by the VA would be the extension of the visuo-spatial cues beyond the physical frame of the interface's screen. In this way, the physical references can point to elements relevant to the interaction in course that are not necessarily inside the digital interface. With the same method of placing the user as the centre of origin, VA's gaze, head and extremities could be used to point out those components that belongs to the user's world but are outside the machine's screen (Wade, 1992; Stainer, Tatler, and Scott-Brown, 2012). For instance, in the case of doing shopping in a supermarket, gestures can highlight the situation in the space of, for instance, the scale, which is located under the scanner but is unknown to many first-time customers. This application would have to face the challenge of what would happen if more than one object outside the interface was placed in the same line of projection of the cue. One more illustration of the potential use of a VA and

continuing with the case of doing shopping in a supermarket, the VA could display the chip and pin device, whose case and location varies across retailers, as an example of introducing the world outside the interface (see Fig. 51).



Figure 51. Example of a virtual agent (VA) showing the Chip and Pin device. (1) The VA is looking straight forward to the customer/user. (2) The animation of the VA starts to direct its head, body and extremities to the side. (3) The deictic cue is completed, with the VA pointing directly to the device and this is displayed on the screen.

In addition, VA gestures can represent the next physical action the user has to perform. For instance, and referring to the shopping example, the way an item has to be weighted or scanned is not obvious to all customers. By capturing the attention of the customer and encouraging them to mimic the VA's gestures, the VA would be able to give the customer a reasonable idea of how the action should be performed, even for the first time (see Fig. 52). The application of the demonstrated paradigms could be also applicable to web design in the case when the user is unfamiliar with the site visited, using VA cue paradigm to indicate the element required to perform an action.

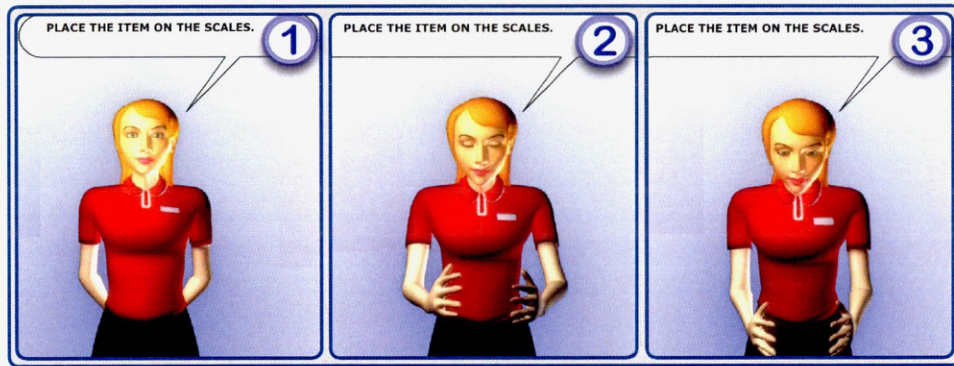


Figure 52. Example of a virtual agent (VA) showing the gesture of how to weigh an item. (1) The VA is looking straight forward to the customer/user. (2) The animation of the VA initiates the gesture to weigh an item. (3) The gesture is completed showing how to place the item on the scale. (Sloan)

Finally, as it was explained in the Chapter 7, a future iteration of the AGILE interface would include physical gestures by the VA in motion, as a proof of their applicability in mobile environments.

8.3.2 Non-biological cues applied in different contexts

The efficacy and nature of non-biological cues, such as flashing lights and arrows, have been compared with human cues, such as gaze. Ristic and Kingstone (2013) states that non-predictive arrows could affect attention in the same way as gaze cues, measured by their impact on observer's behaviour (Tipples, 2002). These attentional effects can also be observed in social context (Bayliss & Tipper 2006) or when individual differences are measured (such as gender, Bayliss, Pellegrino, & Tipper, 2005; Merritt *et al.*, 2007). Furthermore, other differences have also been reported. For instance, arrows do not trigger emotional responses like other human cues do (Bayliss, Frischen, Fenske, & Tipper, 2007). This might be due to the different neural

mechanisms that are involved respectively in gaze and arrow cue observation.

In general, small differences have been reported regarding the biological and social components of gaze cueing paradigm in comparison with arrows. Without being entirely certain whether observers find it easier to orient themselves in the opposite direction of an arrow than a gaze cue (Friesen, Ristic, & Kingstone, 2004; Ristic & Kingstone, 2006 in favour; Tipples, 2008 not in favour), engaging and disengaging attention from gaze cues have more implications than doing it with an arrow. It seems that it is the analysis in isolation what vitiates the results. As it was argued during the explanation of the AGILE interaction style (Chapter 7), it is the context within which the user interacts that ultimately matters, rather than the user (observer) in isolation. There will be contexts in which arrows would be more effective than gazes, for example, in the case of a fire or emergency, where instead of a polite VA indicating the *exit* (VA recreation would also need electricity to perform its actions and in that stressful situation observer's attention and patience to be seen on a monitor), it would be more useful and efficient to see an analogical arrow over high contrast surface (which does not need external power source neither long time to be seen) pointing to nearest fire exit. However, if the intention is to inform about unfamiliar and inexperienced interactions, then politeness, the type of behaviour and the quality of what is perceived matter as much as the message itself.

An alternative would be the use of flashing lights on the objects or items that are relevant for the interaction as it unfolds. Without denying the efficacy of such mechanism of claiming the attention of the observer, again the

argument of the context would be applicable here again. If the focus is on immediacy, probably a flashing light will achieve its purpose of directing user's attention to the object to which it is attached. However, the frequency of observing flashing lights, and the type of activities could create a sort of immunity to their perception. This case is especially true when more than one blinking light is working at a time. In that case, multiple flashing lights could neutralise others making them less effective. In addition, there is another argument in favour of the use of a VA in a more effective way than using single flashing light. Following the guidelines provided in this thesis, the VA is placed in a privileged position central to the area of interaction, in which all surrounding cardinal points can be reached equidistantly and easily indicated from a central point of interest where the UI is placed. A flashing light, however, would need to be physically placed near the object to which the user's attention is to be directed. Therefore, the physical location of the agent gives it a privileged prominence to be seen and to be able to indicate surrounding physical locations.

The ability to interact according to the events or user actions is an additional advantage that could be incorporated in a VA. For instance, feeding back user choice throughout the course of the interaction would be useful to contextualize the behaviour of the VA according to what the user is doing, or needing, or observing, and attend correctly any error or issue that might appear (Martin, Ball, Archibald, & Carson, 2012; 2013).

In conclusion, the paradox of the power of a visual interface is that the modern colour digital display allows for an infinite range of pictorial cues to assist the interaction. This breaks the designer away from the restrictions of a

10 digit keypad and a limited number of button responses with text only display. In this context the best single presentation cues to user attention would be large scale transient flashes or flickers. Yet at the same time these large scale changes reduce the level of certainty and consistency in what is still a machine interaction. Typically at least some users prefer a 'Mise en Place' approach where 'everything is in its place and there is a place for everything' (Brereton, 2013). In shops, there has traditionally been a guide to help bridge these uncertainties, by positioning a human agent with hand and gaze gestures in the main view of the interaction, where there is a chance of bridging the individual interactions into a sustained narrative.

8.4 Reflections on the overall thesis

This project explored how to enhance the HCI with digital interfaces. In particular, a key step was to employ the principles of animation to present valuable information in an animated and artistic way. The VA was the humane component in the user interface that intuitively represent such information via deictic spatial cues. In this line, the pros and cons of agents are next discussed, juxtaposing the use of assistive VAs to intelligent VAs. The former seems suitable for situations when the path to the solution is unknown or not obvious, linking the narrative of the user interaction to the steps for the solution. After, the impact of the new attribution of the responsibility of the interaction outcome is argued to be unprecedented for an unaware inexperienced user, but it is an aspect that can be assumed by a representation of the machine (e.g., a VA). Finally, the traditional 'brute-force' approach of adding more features and buttons to the UI that hypothetically

improves performance is criticised by its lack of awareness of the latest findings from psychological science, for example ever present problems such as short term memory, limited capacity of attention or the necessary distinction between what is seen and what is observed.

8.4.1 Humane User Interfaces

The research questions proposed in this thesis have been answered in three ways: firstly, the incremental evaluation of an artistically animated VA to implement human attentional paradigms to direct observer's attention, activating shifts of attention in the observer accordingly to the interaction in course.

A new style of interaction, AGILE, has been designed which does not require any previous experience nor learning on the user about to use the interface. This style is based on low cognitive load in each decision-making step and the presence of a VA to guide the user through each interaction step. The specification of the OU is necessary for the UID, especially when the amount of potential new users is increasing in parallel to the new types of devices. The AGILE interface is a tangible example of how these OUs are more interested in accomplishing their goals than in learning how to use the interface in depth. The reduction of the cognitive load of interaction steps is the key in the development of interfaces that are going to be used in busy environments. In these scenarios, distractors or user's rush can render inadequate the traditional approach of an interface loaded with too much information unrecognisable to a user. Therefore, it has been found that for the *what to do next* problem present in many UIs, a guidance system could

be helpful to find the item that has to be used in order to proceed to the transaction's next step.

All these findings triggered other research questions. For instance, the question of the degree of empathy a user can establish in a guided-interaction with a VA using a digital interface. The ability that a VA has to produce a smile on the user has unexplored implications when compared with other non-human like elements. The presented research findings point in the direction that one of the keys is not only the usefulness of the VA, but also the way the information is transmitted, which has an added value of likeability when it is made using the principles of animation. Therefore, Animation seems to be a necessary discipline in the evolution of interfaces towards more believable, useful and, in other words, humane user-interfaces (Raskin, 2000).

8.4.2 Pros and Cons of Assistive Virtual Agents

From Latin *animare* (i.e., instill with life) comes the ultimate difference between a VA and other inanimate objects such as arrows or flashing lights that can be potentially used in UI. However, the difficulty resides in how to balance the inherent effects that a believable VA produces on observers. Users attribute intelligence, personality and intentions to the VA that could influence the way the interaction process is perceived by the user. For example, if an arrow mistakenly gives wrong information, it could be a problem caused by the erroneous perception of the observer or the inappropriate design of the system. However, if it is a VA that gives incorrect information, the responsibility, in case of an error, can be naturally attributed

to the agent, since it mimics human behaviour, which is impossible for other inanimate objects. The benefit is that the execution of a reactive role by a VA during the interaction is similar to a situation with a staff member assistant. However, the extent to which a VA might be attributed qualitative capacities that a human inherently possesses, such as responsibility, guilt or reasoning, is still not clear.

Psychology says that anger is probably the best emotion to show in an agent to provoke a reaction on the observer. However, an angry agent producing aversion on the observers would not be useful in the context of inexperienced user guidance. This argument raises doubts about the generalisability of a VA application in the context of a digital interaction. One possibility is an intelligent agent that anticipates user actions. However, this approach contains a risk of offering inappropriate options not according with the interaction in course, or even worse, repeatedly interrupt and disrupt the user because they appear in the wrong moment or at the wrong place (e.g., MS Clippy; MS 1996).

An alternative approach exploits the idea of an ever-present agent, occupying a privileged position and timing in the interaction. In this case, the appearance and usefulness of the agent is linked to the narrative of the interaction, passively offering distinctive ways of help (e.g., spatial visual cues). A real example of this approach can be seen on a Bank Nationale de Paris (BNP) and Paribas Automatic Teller Machine (ATM) (see Fig. 53) in France and an agent on a car parking ticket machine (see Fig. 53) in the Ninewells Hospital in Dundee, UK.

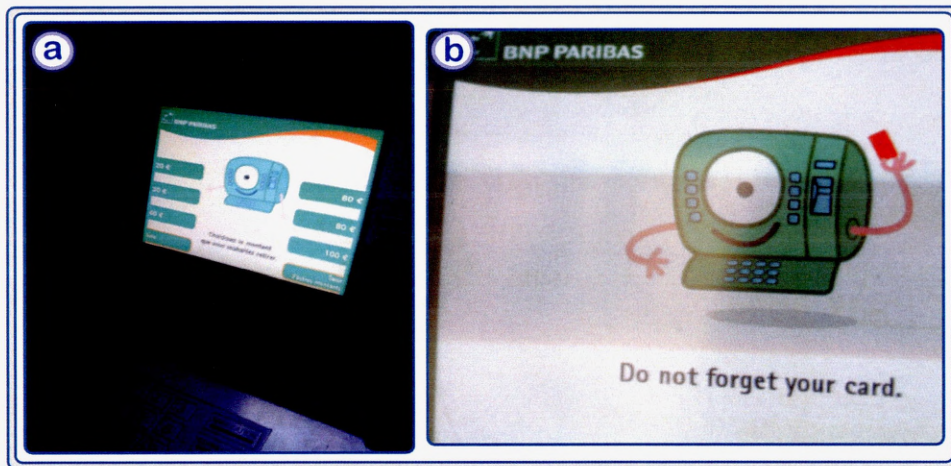


Figure 53. Screen captures of the digital interface of the ATM from the Bank Nationale de Paris and Paribas. (a) The home screen where a ‘cartoony’ agent points with its arms to the different options in the menu distributed in left and right columns³⁴. (b) The same agent reminds to the customer to recover their card and not forget it in the machine. (BNP Paribas)

³⁴ Note that in this case the hands do not actually move, which may be an opportunity missed.



Figure 54. Screen captures of the DaVinci car park ticket machine at Ninewells Hospital in Dundee, UK. (a) An agent indicates with few frames where to insert the coins and (b) where to collect the card. (DaVinci)

The way of helping of these agents address the difficulty of finding elements inside and outside the interface. For instance, chip and pin devices that vary their design across same type of machines, can easily be customized and looked at by a VA via simple frame animations when their use is suitable for the transaction. Fundamentally, the problem is that what makes a good foveal vision does not make a good peripheral cue. Changing the size of objects between periphery and fovea makes individual fixations most accurate but changing a large peripheral button to a small foveal button upon fixation makes the interface confusing and potentially induce change

blindness. With interface design, it is simpler to guide the user around. Exogenous cues are a useful way of guiding attention but they do have limits. Beyond the effective oculomotor range (i.e., in the wide periphery), it is difficult to get accurate resolution from exogenous cues (Smith *et al.*, 2011; Smith *et al.*, 2013) and so additional animation to highlight a location may be needed (see Fig. 51 for an example of an introduction of a peripheral object with tandem use of a central exogenous cue).

Other problems related with short-term memory as forgetting to collect the receipt after a withdrawn from an ATM can be reminded by a VA context-aware. These are all examples of quantitative factors (e.g., reduction of transaction time) that have an impact on qualitative ones (e.g., the notion the user takes from the interaction and the associated business). In this line, Lyle Sander (personal communication, 2010) indicated that after a conversation with a major UK grocery vendor, the differences showed in the Experiment 1 (around a second in favour of dynamic conditions) would scale up to a saving of 1million British Pounds over a year.

8.4.3 Suboptimal states to the solution

The research in using VAs as assistants addresses the need of avoiding complex or unknown UI operations. This approach is evolving in directions that are relevant to UID for OU. Firstly, assistants are now incorporated in mobile devices allowing oral communication (e.g., Apple assistant named Siri, 2011). Secondly, the viability via biometric measures of categorising the user in different states, such as emotion, allows an agent to behave accordingly to the predefined user's state, offering a range of possible

choices or help relevant to the situation. Thirdly, virtual assistants are starting to be used in public areas, providing information and advice to the public in what is called Digital Signage (DS). For instance, animated VAs are increasingly used at airports to inform passengers about the items allowed through security control and how they can be removed and disposed in their corresponding bags or trays³⁵. These DS VAs could be used to safely direct people to evacuation areas in case of emergencies. These scenarios, where indications, advices and emergency procedures are involved would need a careful study from various perspectives. For example, how can a VA make people return if they go in a wrong direction during an evacuation? This issue can be explained by Problem-solving principles (Eysenck & Keane, 2005), which show that when the best solution to a problem is not straight-forward, hidden in a sub-optimal path to the solution, it can be unnoticed. It is the awareness of going towards a worse state locally but better state globally what is necessary to reach what is the solution to a problem. For instance, in a crowd situation is very hard to get people in different directions than intended destinations. Commands such as “Stop, you can’t come this way”, “Stop, this is the wrong direction” and “Stop, the way out is behind you”, can be enhanced with a statement expressed by an agent with the opportunity to create a visual or auditory cue for the message that could include the new direction.

³⁵ At the time of writing, Kastrup Airport in Copenhagen has large digital displays with an animated agent displaying the actions required, however its schematic design has not included facial features. It would be predicted that the addition of eyes to the agent would increased automatic face processing and therefore increased the visibility of the indicated signage.

8.4.4 The ethical concept of responsibility

In HCI studies, the term *user errors* is often used from the perspective of the HCI designer, possibly forgotten that these errors are commonly perceived by the user as mistakes that are inevitably carried out by themselves and assuming the responsibility of such unsuccessful action. However, in some cases, it is the unsuitable design of such digital interaction that is responsible for that unsuccessful action. In explicit terms, many user errors should be therefore catalogued as system's design error. The question is, once a system with potential errors is designed and built, how to remove in the user that impression of mistake, that makes them feel guilty? One way could be to incorporate a VA who would take over that responsibility in case of an error. For instance, in the case of a PIN number that is erroneously inserted in the Chip and Pin device during a digital transaction, the VA could explain in a polite way that the system could not get the number, expressing embarrassment in the VA face (see Fig. 55). This performance and cordial dialogue could potentially remove any feeling of guilt from the user, making them see that it was the machine not the human, who did not perform the action correctly.

These and similar questions confirm that the introduction of VA in any context, e.g., digital interface or digital signage, involves more factors than those primarily considered. The context where the action occurs and how this action is performed matter as much as the content of the message itself.



Figure 55. Example of a virtual agent (VA) ashamed when the user introduces a wrong Personal Identification Number (PIN). (1) The VA is requesting to the customer/user to introduce the PIN at the same time that the chip and pin device is displayed. (2) The system does not get the PIN right and the animation of the VA starts to show an ashamed expression with its cheeks red and asking to insert the PIN again. (3) The animated performance is completed showing an ashamed VA. (Sloan)

8.4.5 Technology evolves but users are still the same

The exponential increase of the amount of mobile phones and the continuous update, upgrade and evolution of their interfaces and operating systems leave many users confused about how to use systems' interfaces that change very quickly. This issue forces the users to constantly learn new functionalities and adapt to new information layouts. However, despite this rapid evolution of technology, users still face the same problems, accentuated when they are unfamiliar with the technology.

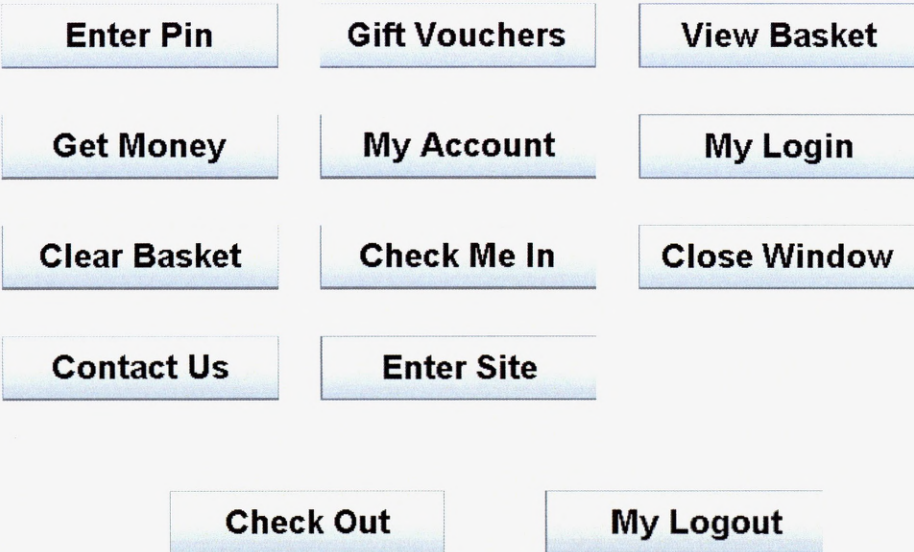
Two examples illustrate how users problem remain the same, despite the technology advances. Firstly, the inherent human limitation of attention to changes has been reported in psychology experiments (e.g., change blindness: Simons & Levin, 1997; *invisible gorilla*: Simons & Chabris, 1999). Secondly, this limitation of the amount of information that can be perceived

by an individual is also manifested in other types of blindness, such as banner blindness in the web (Burke, Hornof, Nilsen, & Gorman, 2005), or display blindness (Müller *et al.*, 2009). These are examples which support the argument that quantitative approaches such as displaying as much information as possible, or placing as many screens as possible in an interface overload human capacity of attending, perceiving and discerning what is around. The latest Google device to be shortly released, *Goggle glasses*, apparently follows this linear approach to potentially overload human user with information. They are designed as the centre of the interaction, ignoring the fact that the user might be possibly walking crossing a street in a crowded city. The question is whether the user, in their daily activities, can pay attention to this disruptive stream of information, and in doing so, is able to balance the great impact that this new type of interaction can entail in terms of health, safety and human interactions. Have all of these variables been taken into account in the design stage of the device? If so, would it be also considered the use of first-time users?

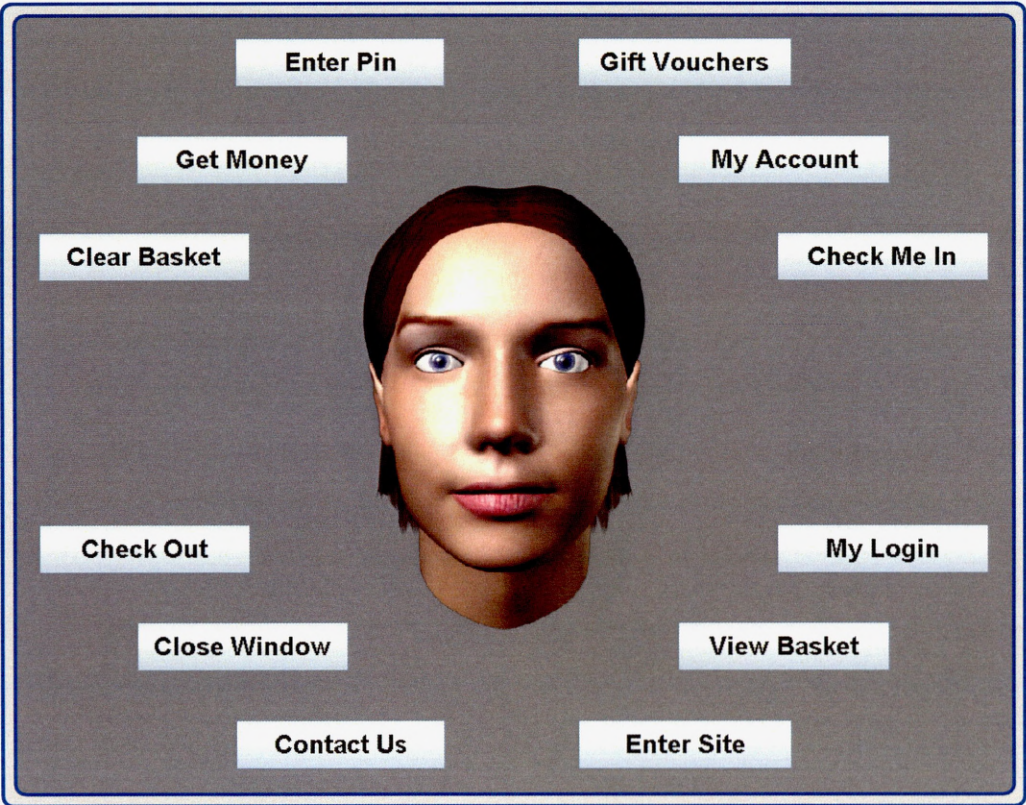
In summary, the traditional approaches that address human interaction with technology have been mainly developed from business or marketing perspectives, without taking into account who the real users are going to be, and for what reasons they are going to use the technology (Martinez *et al.*, 2013). This latter approach is critical, because whenever a new device or technology is released, there will be users without experience in facing their interfaces. Thus, designing for first-time users is, more sooner than later, designing for all.

Appendices

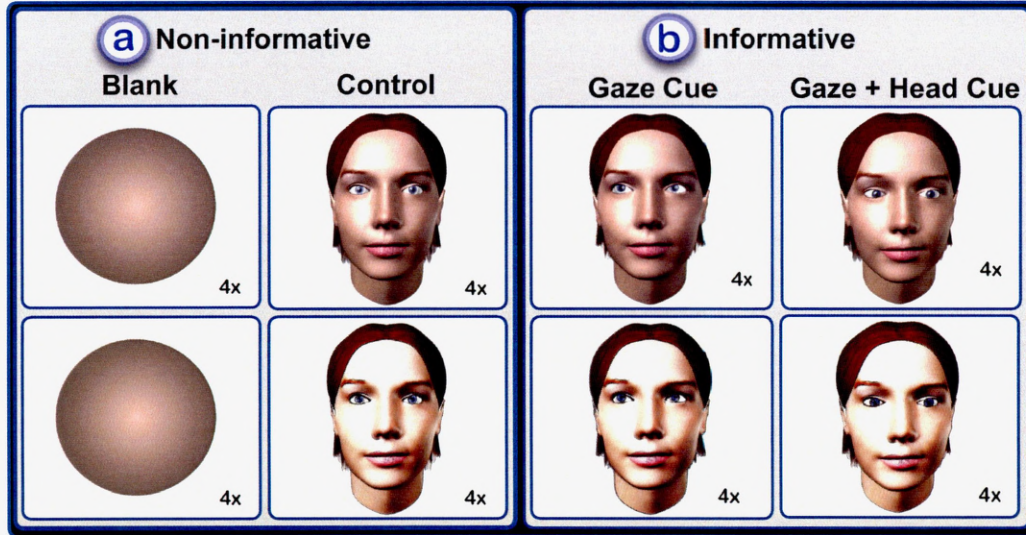
I. Experiment 1 Set of Buttons



II. Experiment 1. Layout



III. Experiment 1. Conditions



IV. Experiment 1 Java Program Data File Sample.

From left to right: Participant number, Age, Gender, Handedness, School, Type of Task (Training / Main), Trial number, Condition (*Ctrl*: Control; *Blank*: Blank; *EyeSW*: Gaze Cue towards SouthWest target; *HeadNE*: Gaze and Head cue towards NorthEast target), Target (*Check Out* / *My Logout*), Time of Space Bar release (ms), Time of item selection (ms), Hit of the cued target (Boolean).

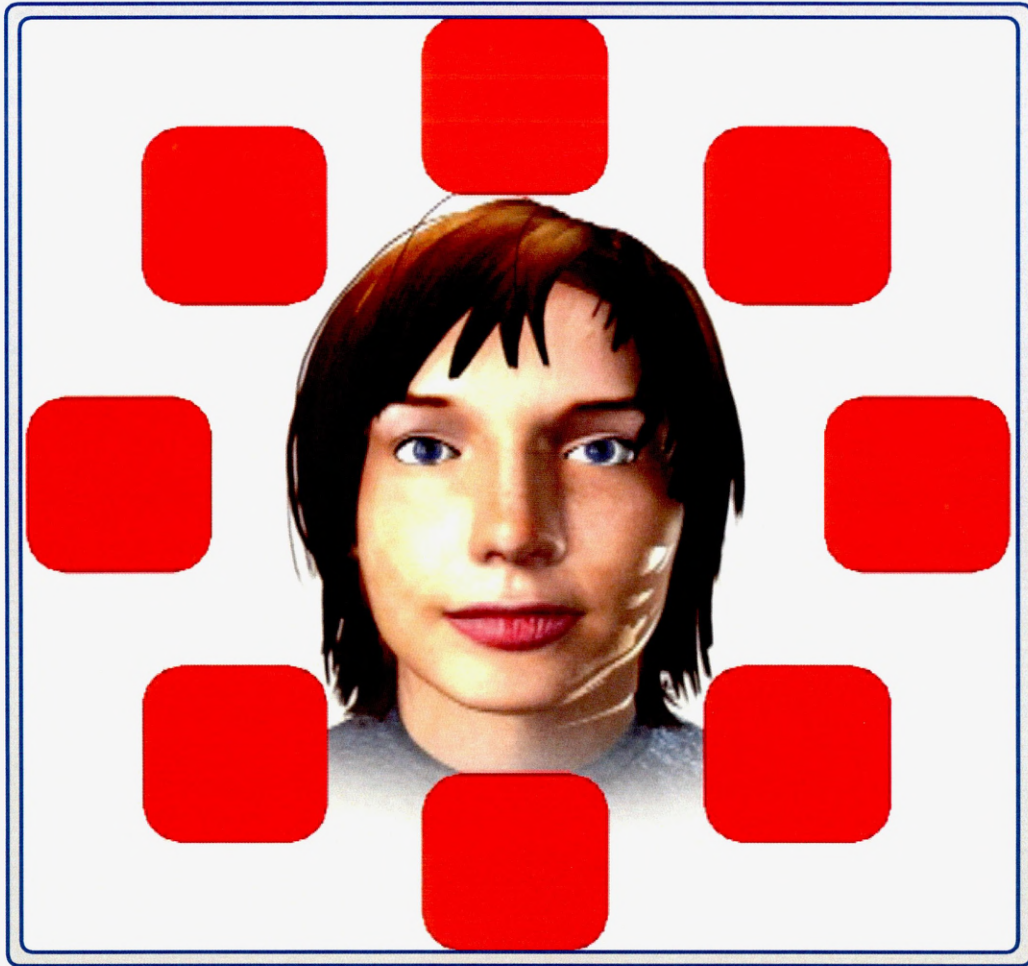
```
[...]
14,42,Female,Right,SHS,Main task,
21,AVATAR_EyeSW_02.PNG,Check Out,1371,1797,y
14,42,Female,Right, SHS,Main task,22,AVATAR_Ctrl_02.PNG,Check
Out,1596,637,y
14,42,Female,Right, SHS,Main task,23,AVATAR_Blank.PNG,Check
Out,4244,717,y
14,42,Female,Right, SHS,Main task,
24,AVATAR_HeadNE_01.PNG,Check Out,2730,613,y
[...]
```

V. Experiment 1 Eyetracker Data File Sample.

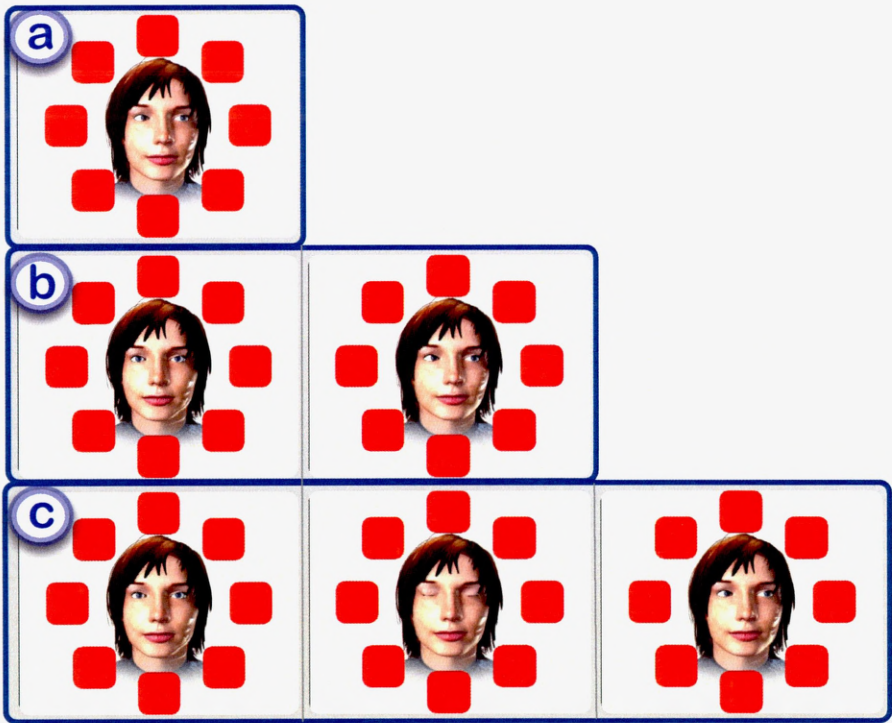
From left to right: Event Type, Trial, Number, Start, End, Duration, Location X, Location Y, Dispersion X, Dispersion Y.

```
Fixation R,1,1,3347234967,3348573405,1338438,386.97,372.64,2,7
Fixation R,1,33,3368371712,3368631405,259693,394.91,237.23,5,11
Fixation R,1,37,3370490288,3370729088,238800,330.27,122.54,3,8
Fixation R,1,38,3370749035,3371028666,279631,388.25,241.78,8,65
```

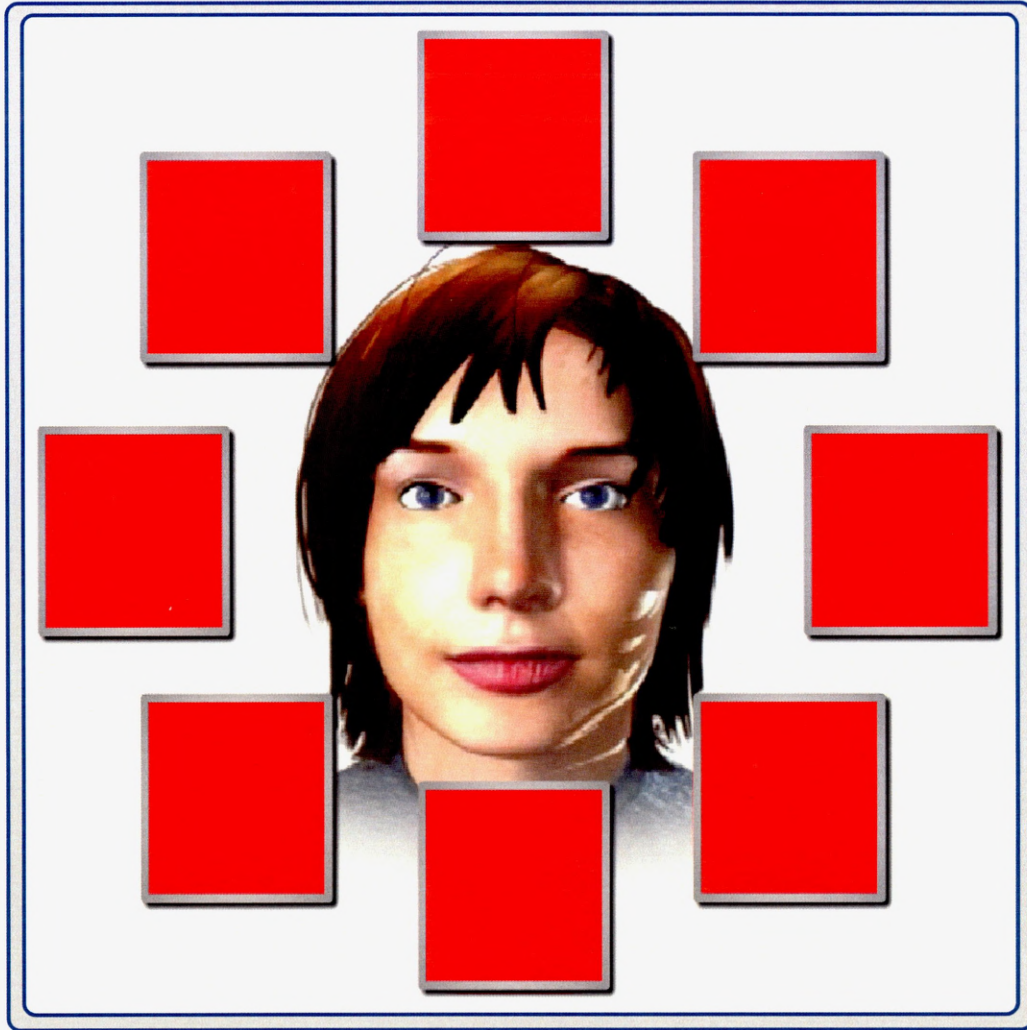

VI. Experiment 2. Layout



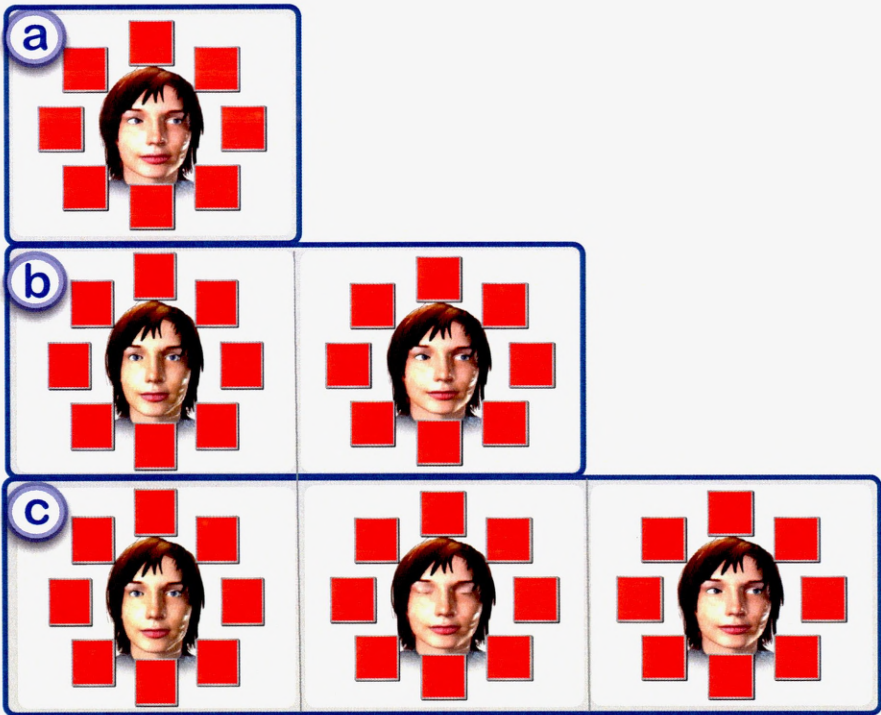
VII. Experiment 2. Conditions



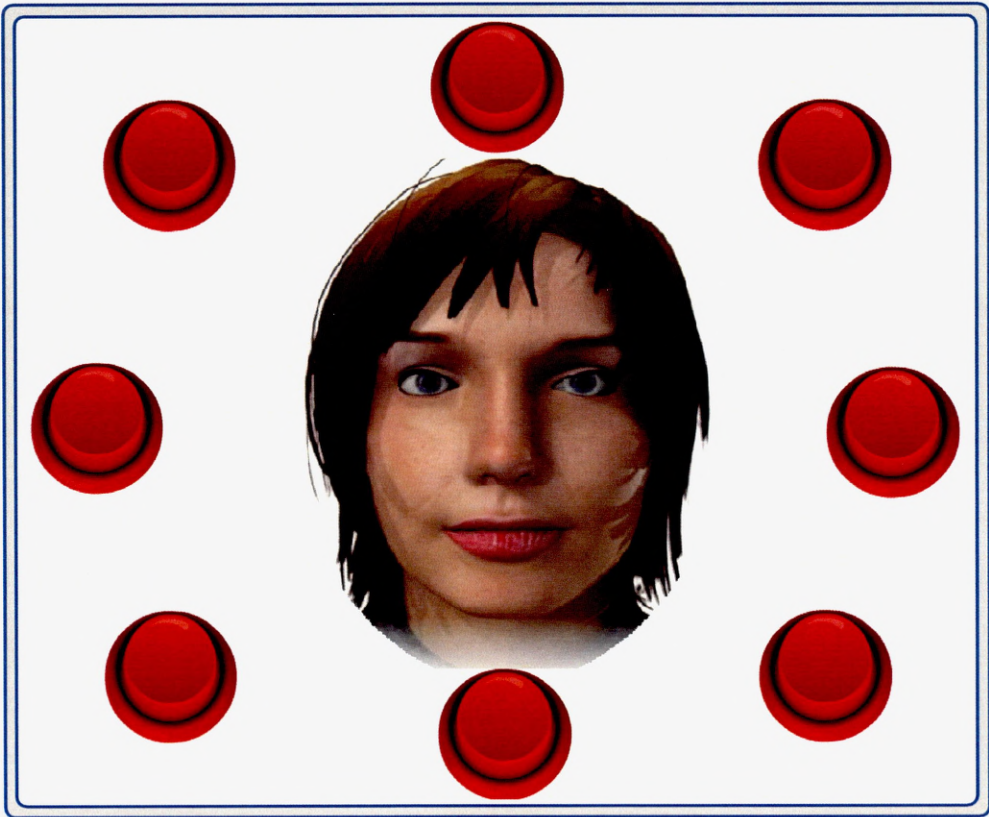
VIII. Experiment 3. Layout



IX. Experiment 3. Conditions



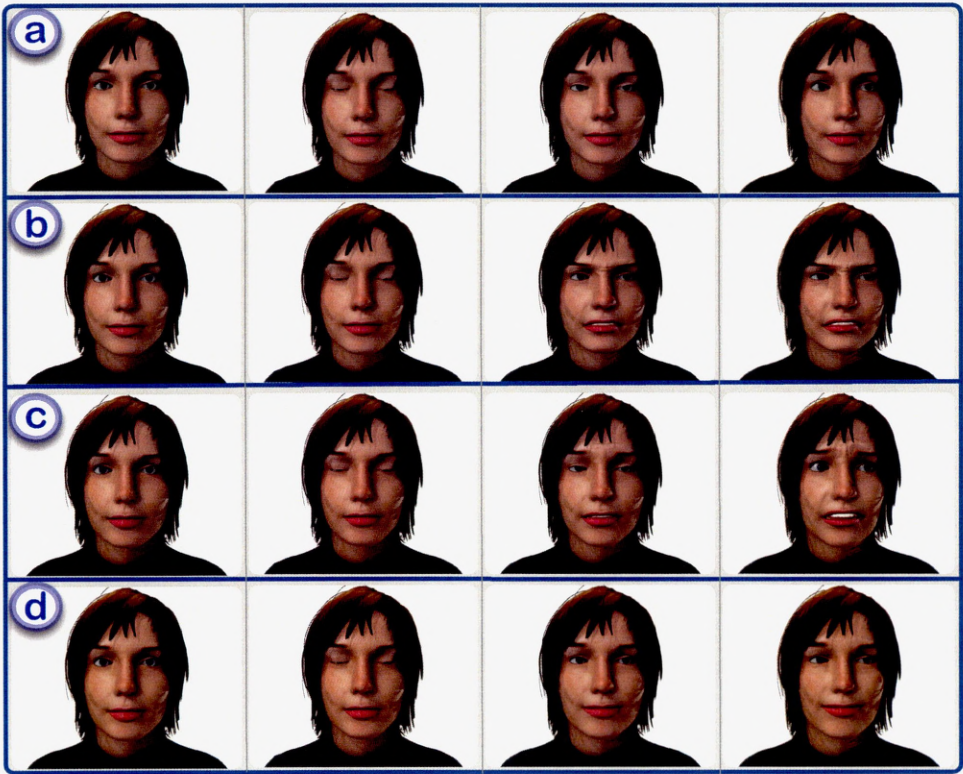
X. Experiment 4. Layout



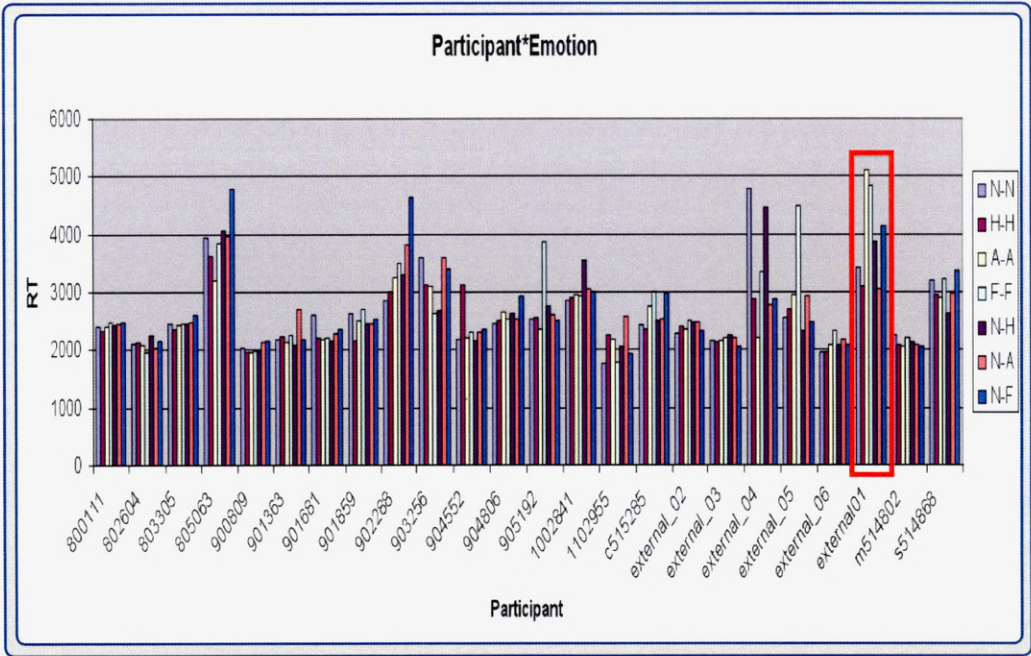
XI. Experiment 4. Conditions (I)



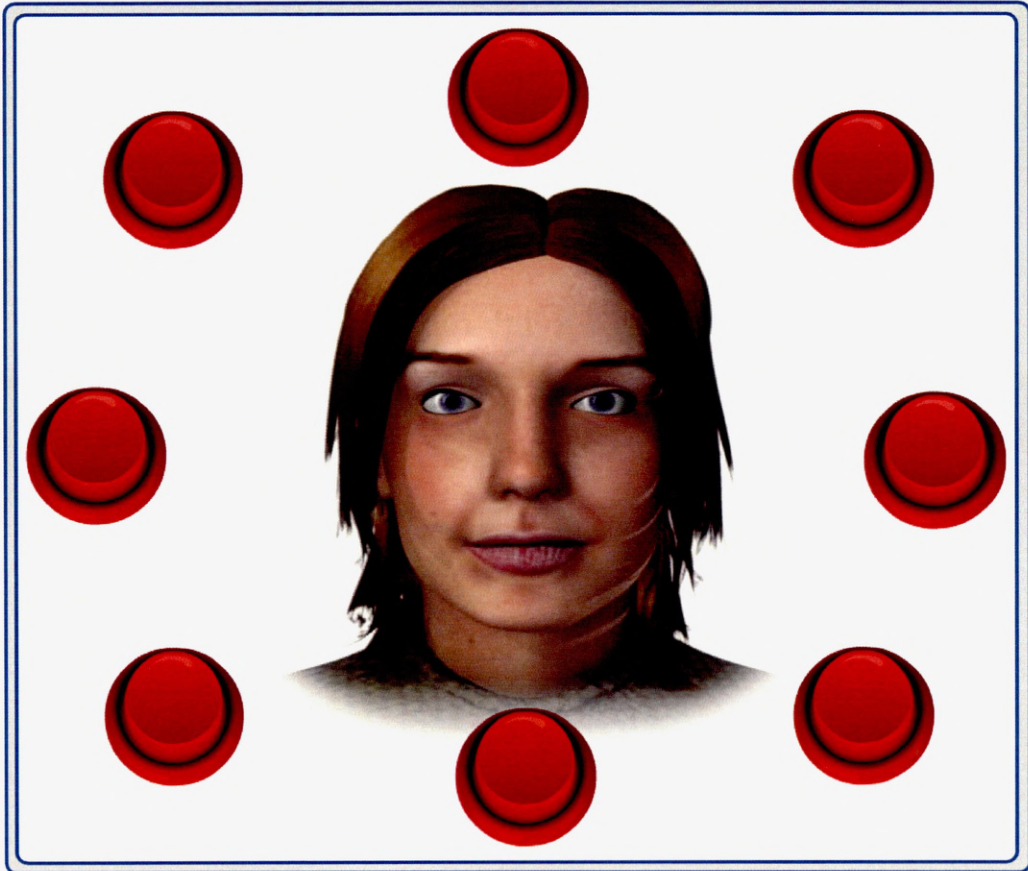
XII. Experiment 4. Conditions (II)



XIII. Experiment 4 Outlier detection (Participant-Emotion)




XIV. Experiment 5 and 6. Layout (I)



XV. Experiment 5 and 6. Layout (II)

Play

Again



How Likeable do you consider the Virtual Agent?

☐

Strongly NOT Likeable

☐

Moderately NOT Likeable

☐

Unsure

☐

Moderately Likeable


☐


Strongly Likeable

XVI. Experiment 5 conditions.

a


Arcs






b


Anticipation






c

Follow through




Head & Eyes




Hair

d

Overlapping



Eyes



Head

e

Slow-in Slow-out

XVII. Experiment 5 Response Time (RT) Effect Size of the seven conditions compared


| Conditions Compared | ω | Size |
|------------------------------------|----------------------------|-------------|
| Follow-through -- All principles | -0,74 | large |
| No principles -- All principles | -0,66 | large |
| Slow-in Slow-out -- All principles | -0,75 | large |
| Follow-through -- Anticipation | -0,68 | large |
| Slow-in Slow-out -- Anticipation | -0,59 | large |
| Follow-through -- Arcs | -0,59 | large |
| No principles -- Arcs | -0,54 | large |
| Slow-in Slow-out -- Arcs | -0,68 | large |
| Overlapping -- Follow-through | -0,7 | large |
| Slow-in Slow-out -- Overlapping | -0,79 | large |
| Overlapping -- None | -0,52 | large |

XVIII. Experiment 6 Response Time (RT) Effect Size of the three conditions compared


| Conditions Compared | ω | Size |
|---------------------------------|----------------------------|-------------|
| All principles -- No principles | -0,54 | large |
| All principles -- Exaggeration | -0,52 | large |

XIX. Experiment 6. Conditions

No-principles



Exaggeration



↑ Typical ↑ Exaggeration

All-principles a + b + c + d + e

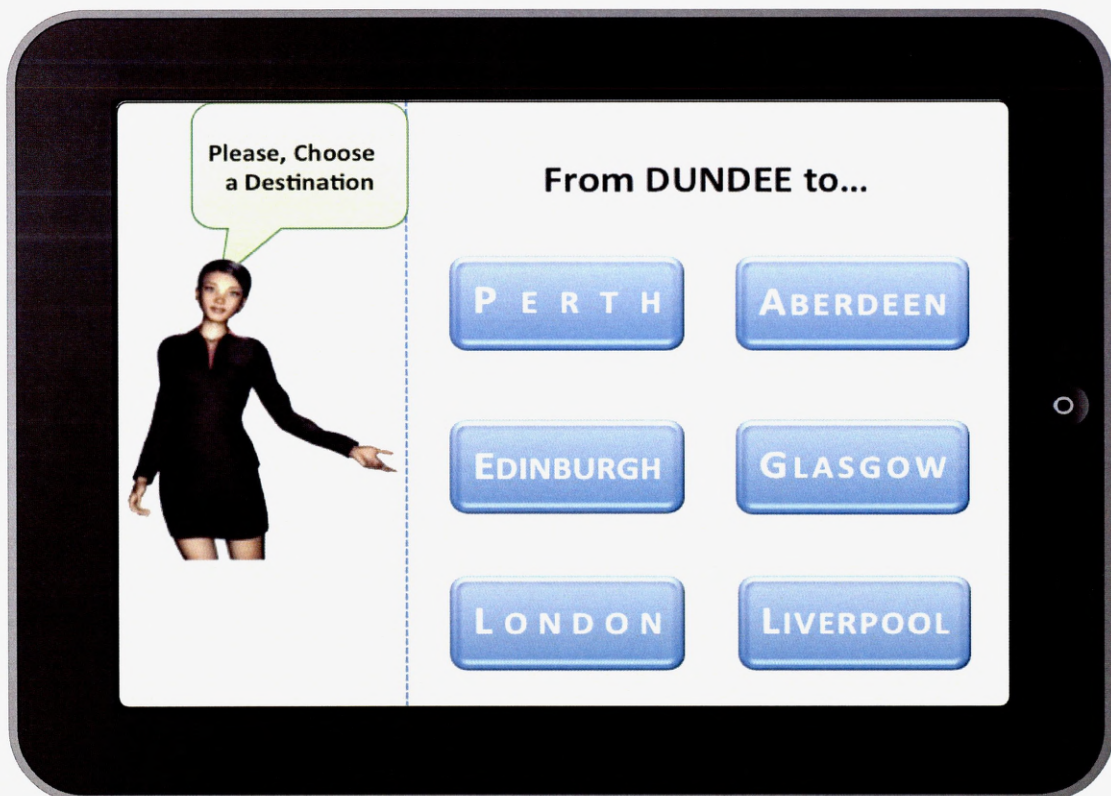
XX. **AGILE Instructions**

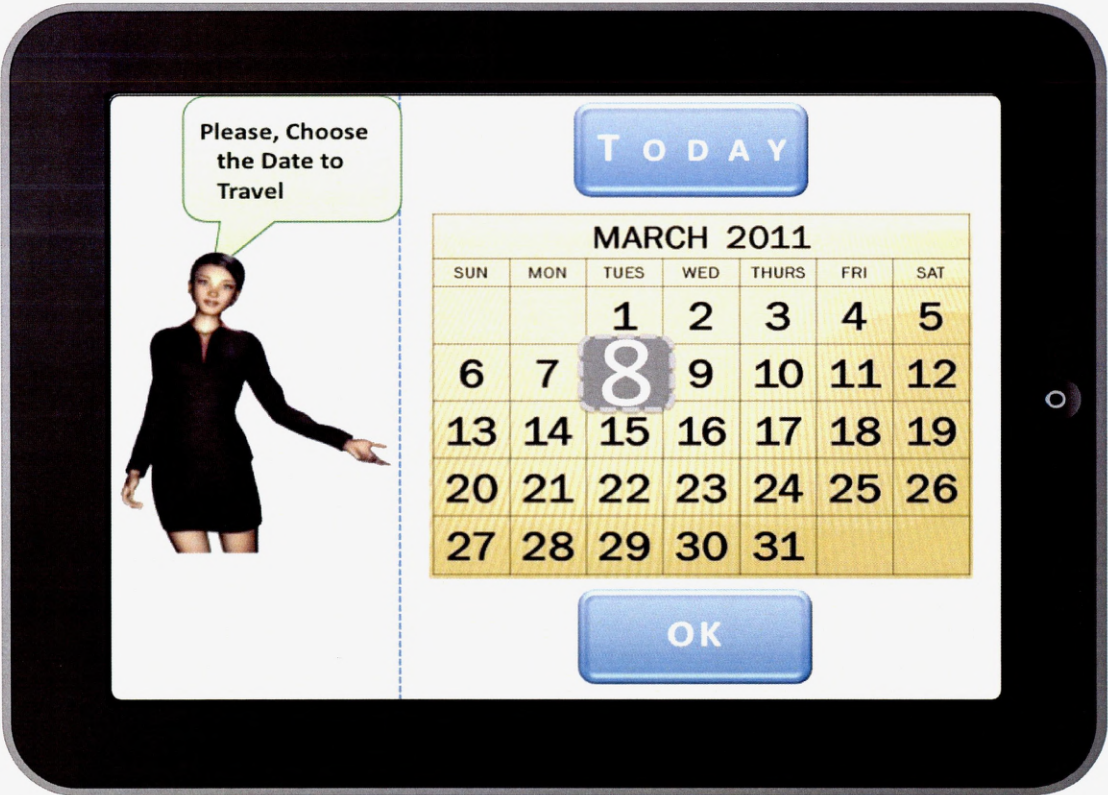
Instructions

- ① Buy a ticket to Edinburgh on 8th of March at 9:00 am or the closest service after that time. The Origin station is set by default as Dundee.
- ② The seat has the following features: Economy class, Forward Facing and Quiet Coach
- ③ Payment by card

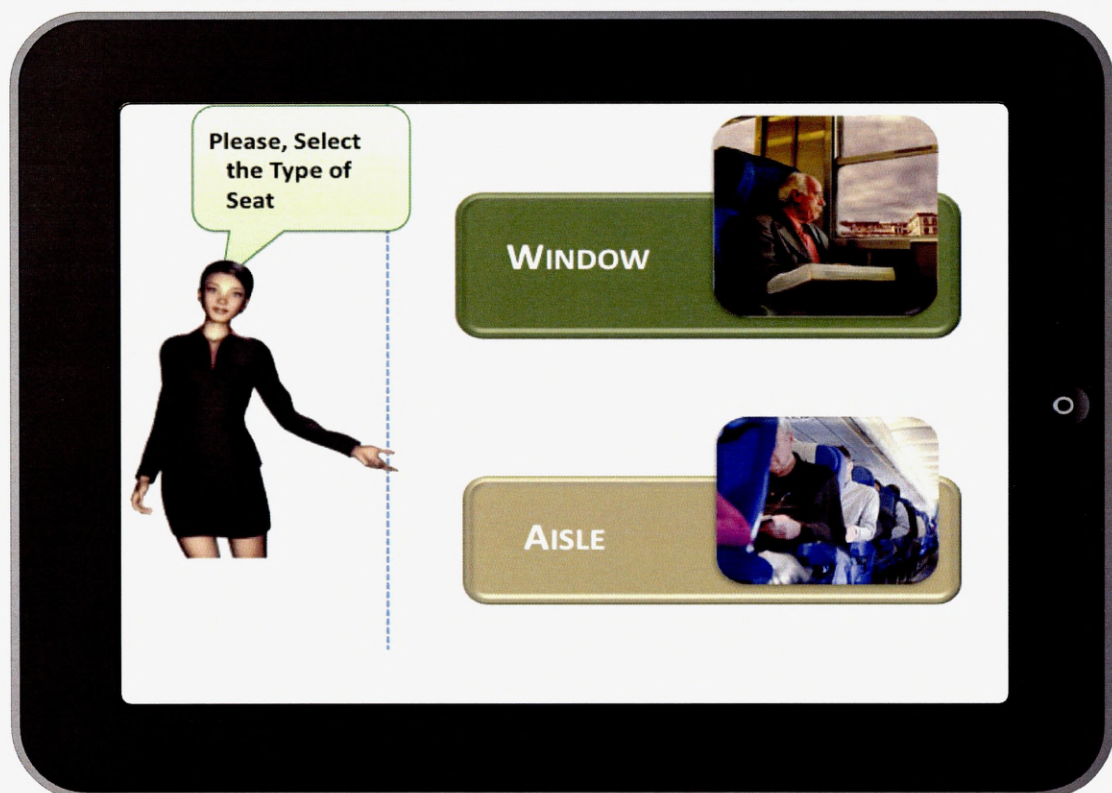
XXI. **AGILE Interface Screen Captures**

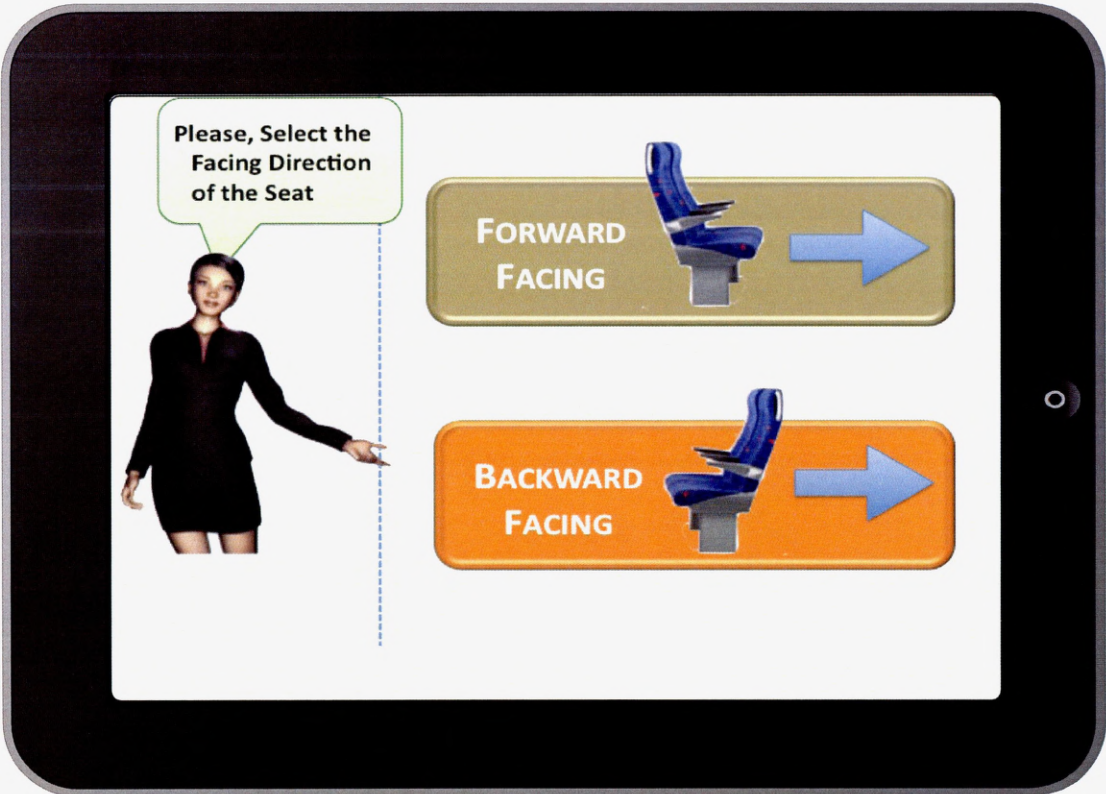


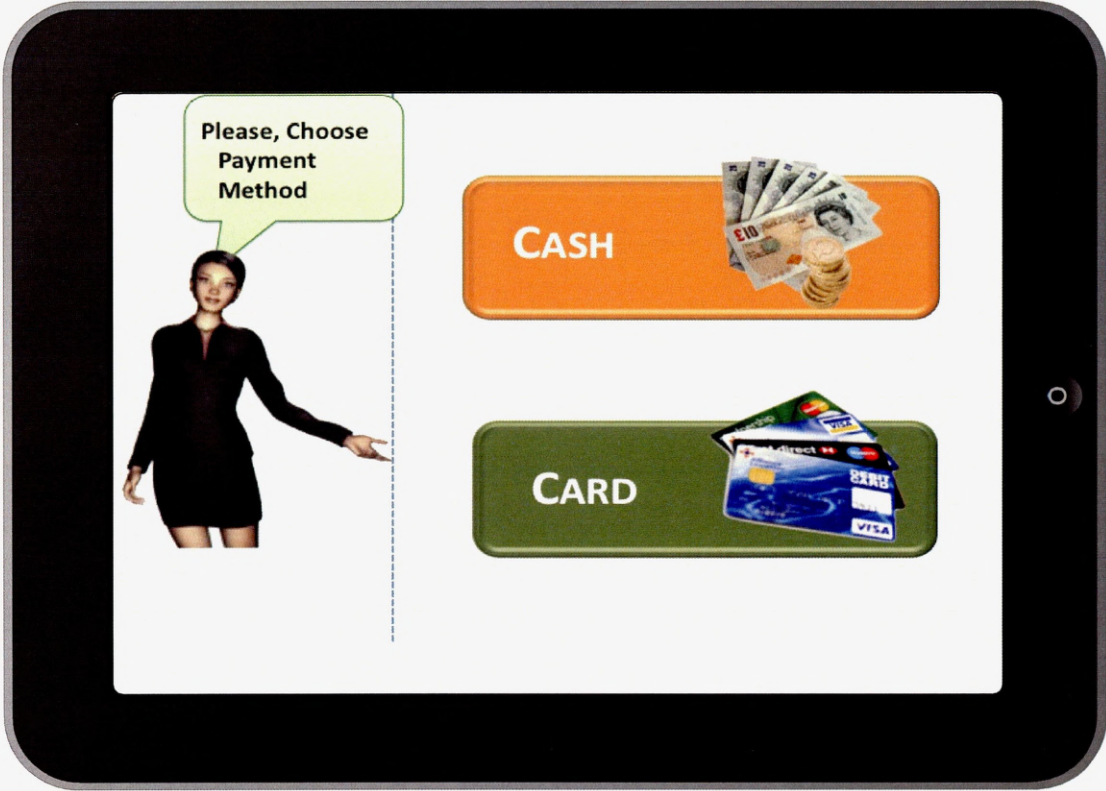




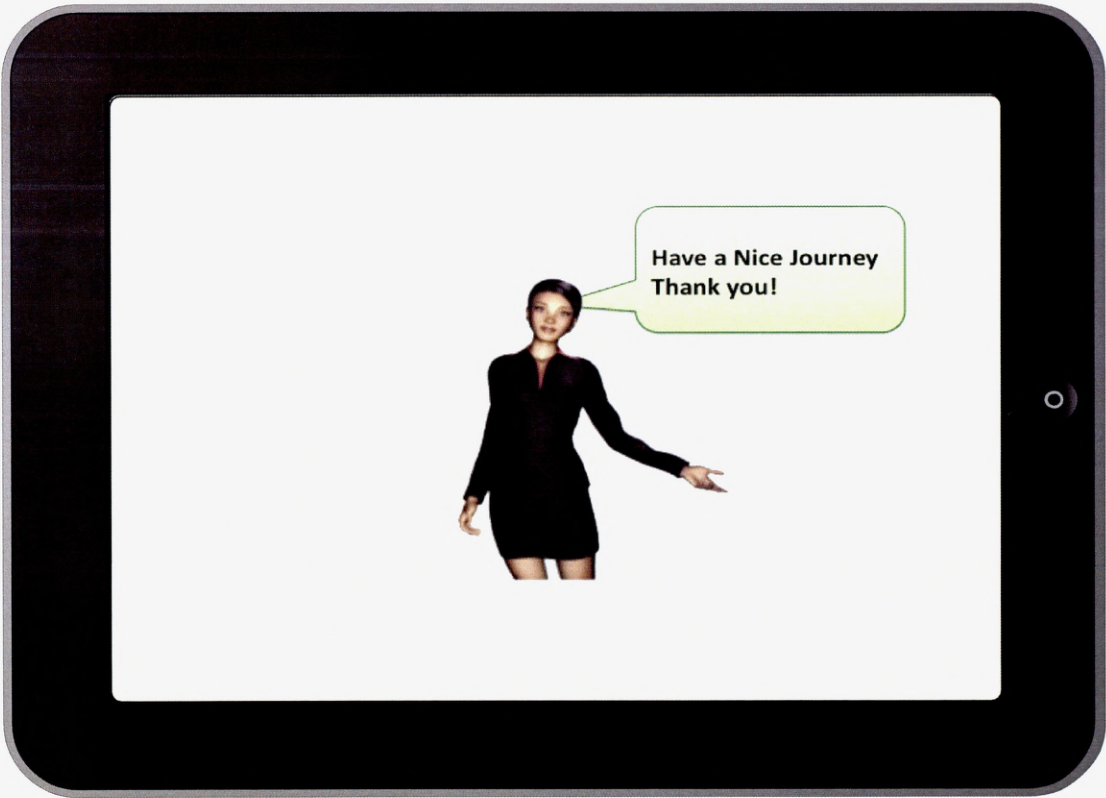




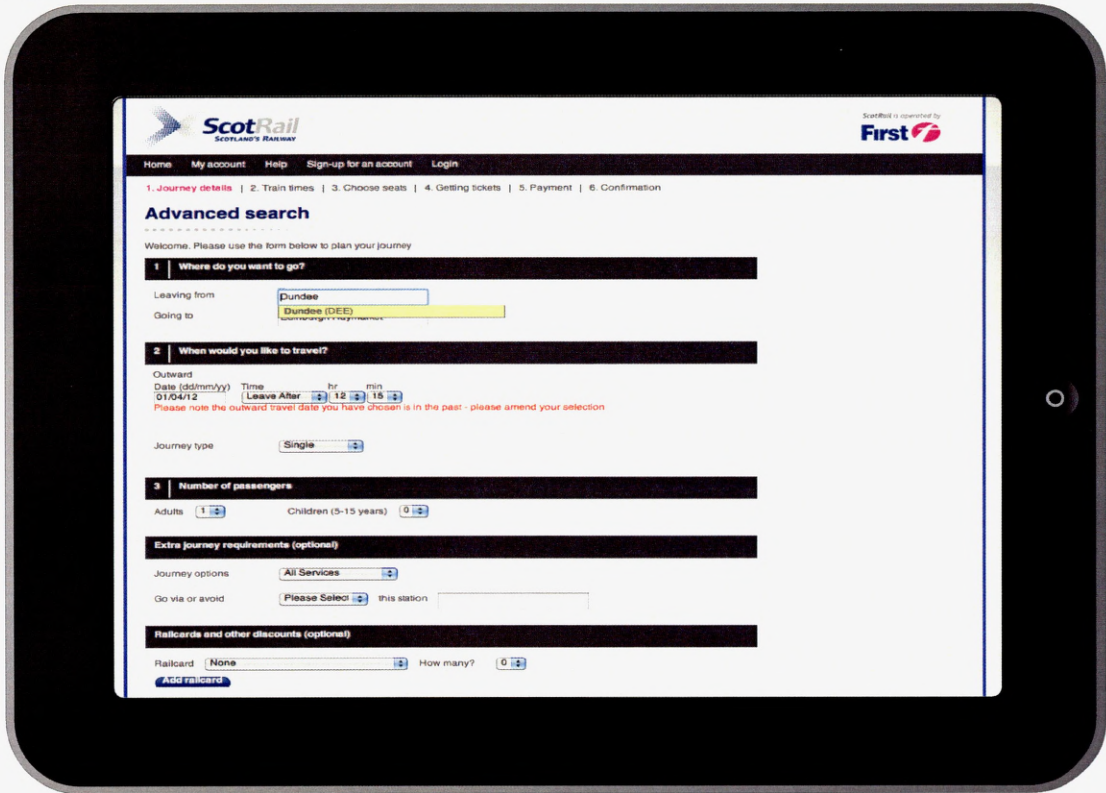








XXII. Train ticket Rail Website Interface Screen Captures



Welcome. Please use the form below to plan your journey

1 | Where do you want to go?

Leaving from

Going to

2 | When would you like to travel?

Outward

Date (dd/mm/yy) Time hr min

01/04/12

Please note the outward travel date you have chosen is in the past - please amend your selection

Journey type

3 | Number of passengers

Adults Children (5-15 years)

Extra journey requirements (optional)

Journey options

Go via or avoid this station

Railcards and other discounts (optional)

Railcard How many?

[Add railcard](#)

Promotional codes (optional)

[Check fares and availability](#)

[Terms & Conditions](#) [Privacy/Cookies](#)

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First

Home My account Help Sign-up for an account Login

1. Journey details | 2. Train times | 3. Choose seats | 4. Getting tickets | 5. Payment | 6. Confirmation

Thank you for choosing to buy your ticket from us. Please check the details below.

Single from Dundee to Haymarket (Edinburgh)

Out
Tuesday 03 Apr 2012
Dundee DEE to Haymarket (Edinburgh) HYM

| | Earlier | | | | Later |
|----------|-----------|-----------|-----------|-----------|-------|
| Depart | DEE 12:16 | DEE 12:34 | DEE 13:16 | DEE 13:34 | |
| Arrive | HYM 13:21 | HYM 13:51 | HYM 14:21 | HYM 14:49 | |
| Duration | 1h 5m | 1h 17m | 1h 5m | 1h 15m | |
| Changes | 0 | 0 | 0 | 0 | |

Anytime Day Single
Travel any time of day.

☐ £22.70 ☐ £22.70 ☒ **Cheapest** ☐ **Cheapest** ☐ £22.70

First Anytime Day Single
Travel any time of day.

☐ £30.20 ☐ £30.20 ☐ £30.20 ☐ £30.20

Journey summary

Price for 1 Adult and 0 Child

Out: 13:16 03 Apr 2012
Dundee (DEE) to Haymarket (Edinburgh) (HYM)
0 changes

- Travel any time of day
- This ticket allows travel on any permitted route

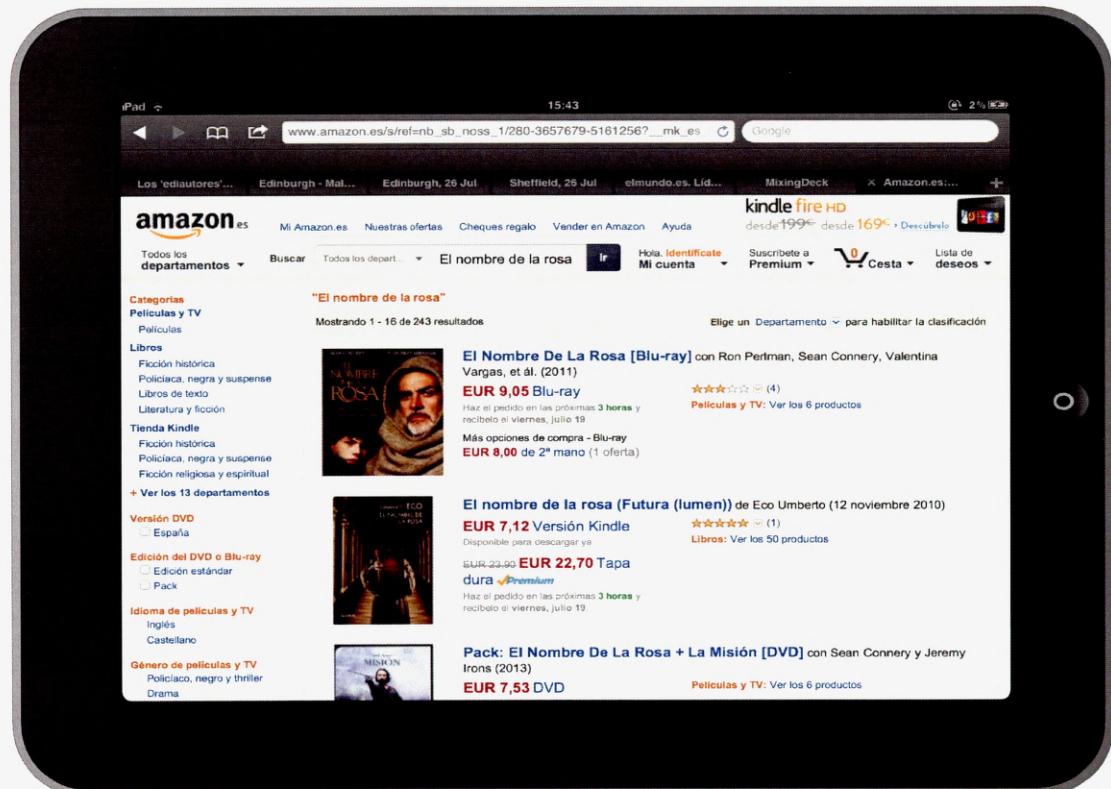
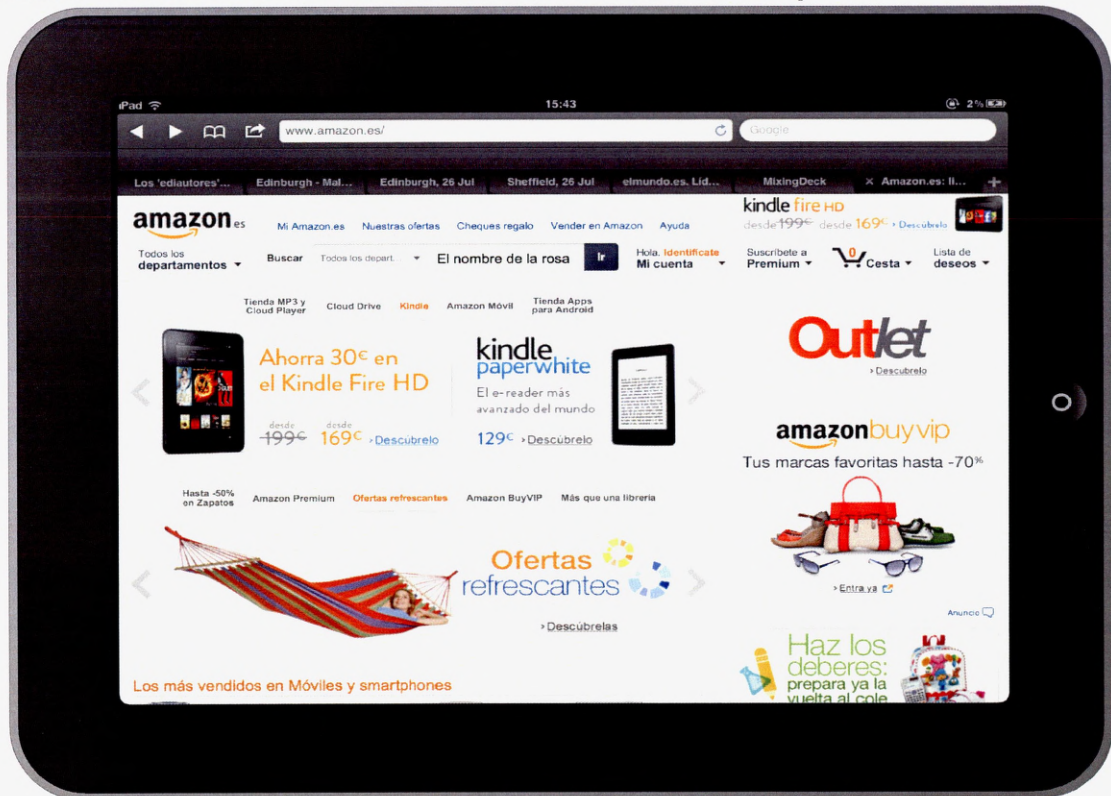
[Annual tickets from £4,148.00](#)

Results are based on the fastest available trains. [Click here](#) to check if slower routes with cheaper tickets are available.

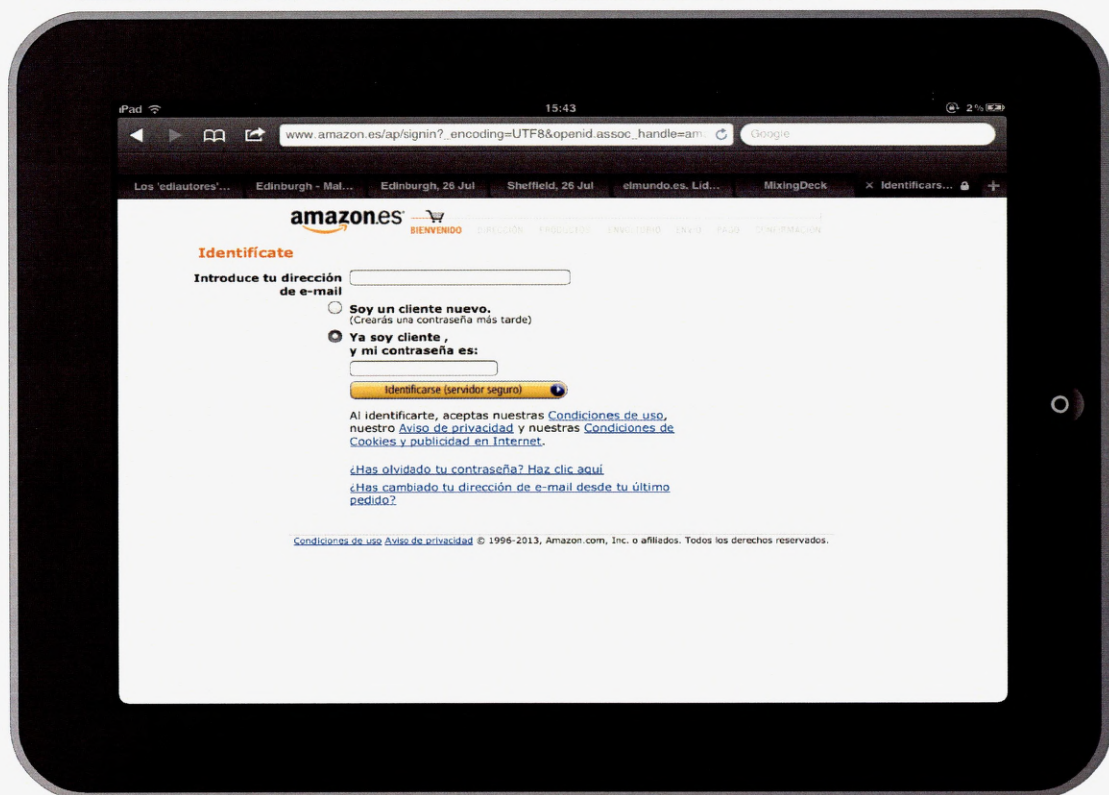
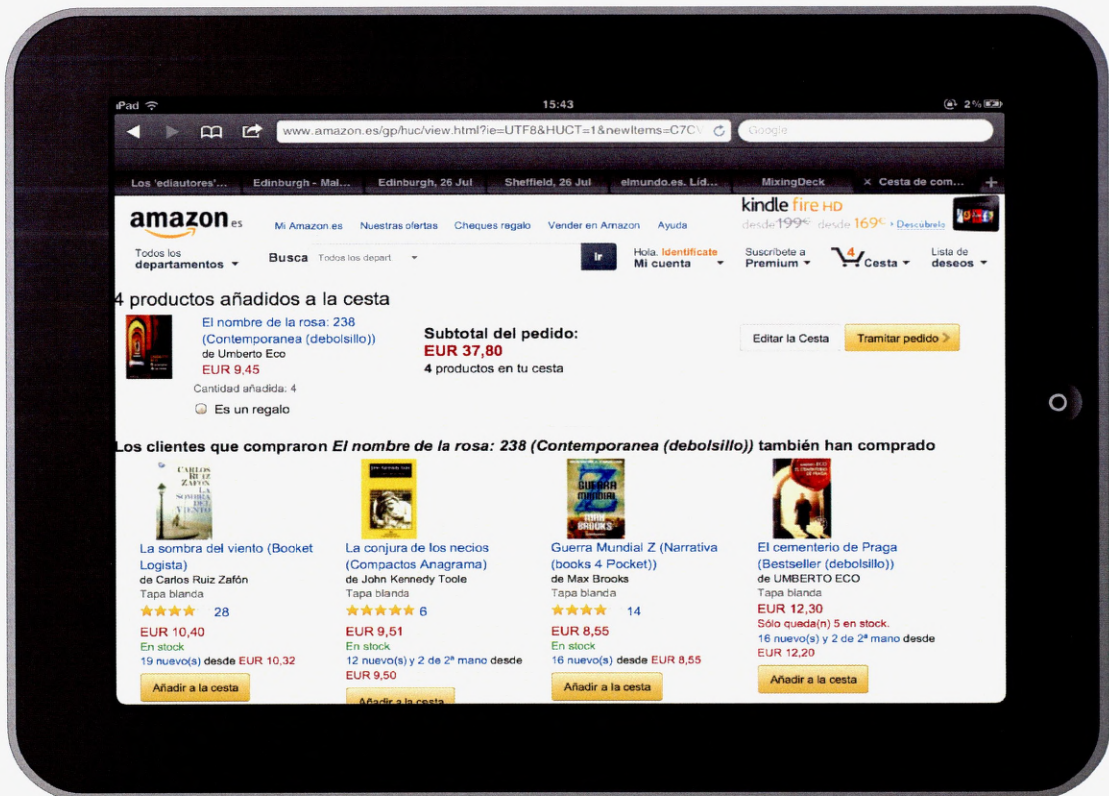
[USDA](#) [Terms & Conditions](#) [Privacy/Cookies](#) [Print](#)

National Rail accredited

XXIII. Book Purchase Website Interface Screen Captures







The pages 317-365, containing the full text of the three published articles cited below, have been removed from the e-thesis due to copyright restrictions:

Martinez, S., Sloan, R., Szymkowiak, A., Scott-Brown, K. (2010). Using Virtual Agents to Cue Observer Attention: Assessment of the impact of agent animation. The Second Int. Conf. on Creative Content Technologies CONTENT 2010: 7-12. November 21-26, Lisbon, Portugal. ISBN: 978-1-61208-001-7

Martinez, S., Sloan, R., Szymkowiak, A., Scott-Brown, K. (2011). Animated Virtual Agents to Cue User Attention. International Journal On Advances in Intelligent Systems, 4 (3 & 4), pp.299-308

Martinez, S., Carrillo, A. L., Scott-Brown, K. C., & Falgueras, J. (2013). AGILE Interface for 'No-Learning Nor Experience Required' Interaction. In User Modeling and Adaptation for Daily Routines (pp. 119-151). Springer London.

XXVII. Occasional User

Carrillo, A., Martinez, S., Falgueras, J., and Scott-Brown, K. (2013). Occasional User. Manuscript submitted for publication.

Occasional user

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Abstract— *Despite User Taxonomy is an unused area in Human-Computer Interaction, originally user classifications have been fruitful for the user-interface community to catalogue and address the needs of different user categories. Parameters such as previous experience and skill with computers have categorised users in distinctive groups, such as novice, intermediate and expert. However, historically unskilled users who occasionally wanted to use a computer for a punctual purpose faced an unavoidable obstacle of needing to know computer concepts and experience with the interface. The ubiquity and diversity of devices that, compared with with WIMP-legacy interfaces, have a greater focus on Usability and Accessibility, are greatly changing the spectrum of current users. These new technologies incorporate new functionalities such as touch gestures, becoming an ideal platform to provide an occasional and uninstructed use of technology. This work revisits, updates and fills the gaps on previous user classifications, leading to the introduction of a new category, the Occasional User, that holistically shapes a definite group of users non-existent in earlier classifications. The specification of the Occasional User will help user-interface community to informatively address the challenge of designing for a user without requiring a previous knowledge of the interface.*

Keywords: occasional user, user classification

1. INTRODUCTION

The main goal of this paper is the description and characterisation of the *Occasional User* (OU), a user who wants or need to use a system but does not have previous experience with its interface and ignores if they will use the system ever again. This type of user has always existed but, for several reasons, has been put aside in most classification of users. The reasons for such exclusion originally when the computers started were the difficulty of learning command languages. After, user interface design (UID) principles and guidelines assumed that a prospective use of the same system is certain. This assumption has been the main obstacle for the use of digital systems by users without experience, who wants to occasionally achieve a goal performing a single transaction.

At present, few factors might favour the design of systems for its occasional use. Firstly, the evolution of technology: Graphical User Interface (GUI), Internet, and Touch interfaces; changes that have allowed the introduction of new kind of devices and new styles of interaction, increasing the heterogeneity and the potential number of users. Secondly, the incorporation of Accessibility, Usability, and Inclusive Design

principles. Thirdly, the increase in number and type of different context of use, from shopping centres to airports and supermarkets, thanks largely to the introduction and expansion of mobile and Self-Service Technologies (SST).

In the next section we highlight the importance of user classification in the design of interactive systems, arguing that considering an average user as a general approach alienates user differences, potentially excluding non-archetypical users. In section 2, widely accepted classification of users are described, underlining their strengths and weaknesses. To evidence the range of previous work on users without experience with a system, a uniform approach across different authors is presented, underlying coincidences and divergences among the variables on which they based their categorisation of users in general, and inexperienced users in particular. Several reflections about the previous point are made in section 3. In section 4, the OU is presented, describing and assigning values to their representative parameters. Finally, in section 5, the overall conclusions in the context of user models, interface design and future work are discussed.

1.1. Why a User taxonomy is useful for User-Interface Design

Technology designs are addressed to the knowledge of their community of users. Therefore, classifications of users provide interface designers a catalogue of user needs and skills that can positively inform User-Interface Design (UID). To *know the user* is an essential principle in user-interface design (UID) (Hansen, 1971). The reasons for such importance are: more usable systems, more appropriate interfaces, less trial and error in design, and reduced user training (Potosnak, Hayes, Rosson, Schneider & Whiteside, 1986).

A classification of users helps in knowing the potential user of an application. For instance, Schneider (Schneider, 1981) created a user classification of five categories running from the person who uses the system without understanding what they are doing, *parrot*, though *novice*, *intermediate*, *expert* and to *master*. This five-stage model was called *prescriptive* because it provided designers with valuable information about the level of expertise users could present when using a system.

As it will be seen, classifications of users are objectively useful for several reasons. First of all, they contribute to a better understanding of the end-user. A reliable classification should include the most representative and relevant characteristics of the user. The range and associated values of these characteristics contribute to draw an appropriated map of user needs,

virtues and possible deficiencies that should be pillars of all stages of the design process (ISO 9241-210, 2010). Therefore, a well-defined set of variables is important to conform to what a user potentially can do using a defined system and could expect from it, what are their needs, and how to best prevent and deal with possible errors. Classifications of users ease the study and work of designing for users. Additionally, there is a time factor associated to every classification made. They serve as a reflection of how technology has been changing habits of the user population, showing collective advances on one hand, and issues on the other, both contemporary to the time the classification was made. It also reflects the other flip of the coin, how evolution of user population's society and their costumes have established the direction in which the technology has evolved.

1.2. The misleading concept of the 'average user'

When in search of the most representative characteristics for the target users of a specific application or system to be designed, there is a tendency to build a unique and general representation of the user for the design of the system. The discussion point is whether this concept of an *average user* is convenient to fairly represent the heterogeneous spectrum of users in general, and a special type of users in particular. In the case of users without Information and Communication Technology (ICT) experience, it does not seem to be the case.

Norman alludes to the average user as a *representative user* (Norman and Draper, 1986). This representation is meant to illustrate a prototype of the intended user for the application interface. As result, the design cycle of technology interaction has been predominantly evaluated from the perspective of a homogeneous user type. In contrast, continuous introduction of new technologies have altered and extended prevalent scenarios of use, increasing the number of users and, more importantly, diversifying those user stereotypes. This means that, at present, traditional user profiles do not entirely reflect a spectrum of users that is constantly growing in variability, and requires a fairer analysis of user needs and context where technology is used.

Whilst it is true that the incorporation of Accessibility (US Amendments Act, 2008; McDonough, Ladner, Roth, Scadden & Vanderheiden, 1988; Stevens, Cruz, Marks, & Lakatos, 1998; US Rehabilitation Act Amendments section 508, 1998) and Usability principles (Hewett, 1986; Hix & Hartson, 1993; Nielsen, 1993, p. 358) have increased heterogeneity in design for users of mainstream technology, in comparison, there is still a reduced number of effective applications developed for specific target users, such as elderly, children, disabled, or any with special needs (Ling, 2008; Marscholck et al. 2007). Quoting Langdon and Thimbleby (2010, p. i):

Much of the accepted research [on usability work], is likely to be inadequate for informing user interface design in the future, and certainly inadequate for

informing inclusive design of user interfaces.

On the other hand, fields such as Universal Design (Goldsmith, 1976) and Inclusive Design (Savidis & Stephanidis, 2004) deservedly attempted to equilibrate the User Interface (UI) research scene, increasing the quality and number of designs for those special types of users, laying aside the traditional marginal approach of supposed user uniformity.

The problem is that different categories of software, hardware and context of use may easily result in a different average user for each one, because what average user definition means in one context may differ in another. For instance, an average user of an old typewriter with an analogical and mechanical interface does not exactly fit into the same parameters as an average user on a daily shopping trip to the supermarket, using a Self-Service Checkout with a touch interface. The experience of the user in the first scenario, may or may not translate to the context of the second, but both users could be the same person. In addition, rapid changes in device technology made it difficult to say if the traditional computer model based on the average user is applicable for other devices, or other types of users, or different contexts of use. Device technology's evolution also requires developments in the accessibility, usability and interaction techniques of such devices which are not always covered by the average user stereotype. Considering a realistic target set of users should include variability in their spectrum.

In summary, the arguments discussed above produce serious doubts about the utility of the concept of average user in UID. All these issues clearly suggest that a relationship between the cognitive and physical human aptitudes – in conjunction with new types of devices, and their scenarios of use have to be devised.

1.3. Experience and learning as criteria to classify users

UID has traditionally used two key factors to typify the user: experience and learning. These factors are typically assumed in a sufficient level to consider unnecessary to include precise explanations of how to use the interface, what supposedly could be time consuming or disturb the experienced user. Nowadays, some software applications include tutorials and demonstrations (whose visualisation can be voluntary or prescribed) showing how to use the interface. However, the number of such applications is still reduced, particularly in the case of inexperienced users or those with special requirements, such as elderly.

To build a successful interaction style, it is important to understand the relationship between user, experience and learning. Studying traditional user models allow to find the reason of why users outside the mainstream are not summoned. The Fig. 1 illustrates one of the underlying concepts of user classifications. Given a user and an interface, it plots the knowledge a user acquires throughout the repeated sessions with the same interface. The graph in the figure represents the accumulated experience of use (x-axis) and the learning about the functionality of the system (y-axis).

The above discussed average users (previously seen in sect. 1.2, p. 2) would be hypothetically placed in the centre of the curve (region B), representing the set of users with an average experience of the system. This central region of the distribution delimits other two different sets of users with less and more experience respectively (region A and region C). Novice users or other users with special needs do not fit into any region with certain amount of experience and knowledge (B or C), being placed in the region with least knowledge about the interface (A).

The idea of knowledge obtained through previous experience or expected repeated sessions, explains the lack of success of users unfamiliar with the interface. UID design is usually based on the assumption that a user will have more than one session with the same interface, providing through this mechanism of repetition the sufficient knowledge to know how to use it. This leads users to apply simple strategies such as trial and error, which are particularly not optimal during the first-time use. This is the reason why there is a clear mismatch between the models based on average users and those that address user needs out of the scope of average, such as elderly or special needs users. The result is that mismatched users perceive the inadequacy of interaction, from which unsuccessful users may feel fear of technology use or see themselves as incompetent users.

2. USER CLASSIFICATION LITERATURE REVIEW

The literature review about non-average users is divided in two subsections. The first presents and describes the differences across a wide range of the most widely accepted classifications, with special emphasis on users without experience in ICT. The second analyses some key aspects from former user classifications that participate in the definition of the new type of user presented in this paper.

2.1 Traditional user classifications

Traditionally, classifications of users have relied on specific variables to group users by differentiable characteristics.

It is observed that the precursor of user classification historically came from database research context (Vassiliou, Jarke, 1984), to assess the best approach for query languages and data management. Problems associated with using command languages (Whiteside, Jones, Levy, Wixon, 1985) to communicate with the machine, triggered the studies to find best practices. At that time, it was of main concern how users could satisfactorily deal with the information to subsequently have the least number of errors and dissatisfaction doing queries. Therefore deep analysis of information queries were carried out to reduce number of errors and dissatisfaction on outcomes.

In the literature, it is common to find across independent classifications similarities in the names used to classify these groups of users. However, it is less common to find a clear description of the variables used for such division. There have been several user classifications widely accepted in the research literature and six of them are chronologically spotlighted here: Martin's, Shneiderman's, Schneider's (already explained in section 1.1), Moran's, Nielsen's and

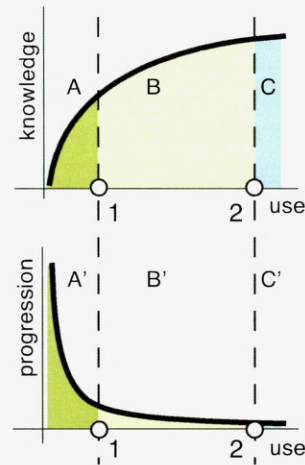


Fig. 1 Knowledge progression of the average user of a system. The x-axis denotes accumulated experience of use; y-axis learning about application domain and functionality of the system. The region A (left-hand side on both graphs) represents where the knowledge is rising with the use and the highest progression tendency. The region B (middle on both graphs) represents where the knowledge rate is reduced, resulting in a digressive progression. The region C (right-hand side on both graphs) is where the progression tends to disappear and the knowledge remains constant. Point 1 is where the knowledge reaches the peak. Point 2, where the knowledge progression ends.

Turoff's. Although other classifications are here omitted, these six classifications are considered to fairly frame the scene in the literature and draw a true picture of values and concepts used for their categorisation. Where possible, the variables in which such classifications built on their criteria have been stated.

Martin (1973) implicitly considered the *frequency of use* of the system by a user as a variable for classification. He described the computer application use on intermittent times because users are (at that time) most likely to be doing different tasks rather than using a computer. It corresponded to the years where computers were not omnipresent and the majority of the working time was spent in non-automated tasks, such as electro-mechanical, manual, or verbal ones. Training on specific computer application usage was little or non-existing, and the interface should have been designed to be natural and intuitive, to avoid user's confusion and rejection of the system.

Shneiderman's (1980, 2005) explicitly based his classification variables on *user knowledge* and implicitly on *frequency of use*. The user spectrum is divided into three distinctive categories: novice or first-time, knowledgeable intermittent, and experts frequent users. Two types of knowledge are differentiated: syntactic, which refers how to use a particular system being device-dependent; and semantic, which relates to computer and task concepts and it is device-independent. The origin of such classification is due to the evaluation of natural language in the use of the interface would be useful for infrequent users or novices, who had high semantic although low syntactic knowledge (Van Dam, 1997). A partir de la 4ª edición, ya en el año 2005, dejan de hacer referencia al sintactic knowledge y al semantic knowledge about computer concepts, a los que pasan a considerar uno solo: the interface knowledge. In next sections more details about Shneiderman's are provided.

Moran (1981) presented two main categories of users: expert and novices. The classification was a two dimensional division, based on the variables *user knowledge* and *task structure*. User knowledge was related with the frequency of use of the system and skill level of the user. By task structure Moran meant the range of actions a user can and cannot take, whose most representative component is the interface. Moran argued that the novice is vulnerable to many task structure variations, in contrast to the expert who is relatively unsusceptible. Novices were focused on how to overcome the task and how to learn the use of the interface. Experts were skilled in using the application and, compared with novices, barely had cognitive load doing it. Both types of users would likely have used the application in the future.

Nielsen (1993) proposed a three-dimensional analysis of users that draws distinctions in terms of *domain knowledge*, *computing experience* and *application experience*. However, he clarified that users' experience regards the specific UI is the dimension that is normally referred to when discussing user expertise. For Nielsen, *casual users* are the third major category of users, besides *novices* and *expert*:

(...) [casual users] are people who are using a system intermittently rather than having the fairly frequent use assumed for expert users. However, in contrast to novice users, casual users have used a system before, so they do not need to learn it from scratch, they just need to remember how to use it based on their previous learning.

Nielsen also talks about *complete novices*, those without any prior computer experience. However, he argued that at that time, they were less common than in the early years because many people have used computers and already know how to use them.

Turoff (1997) considered that a classification of users plays a functional role in the design of systems,

distinguishing a great variety of users: *novice, casual, experienced, intermediaries, frequent, operators, routine, power, problem solvers, and real time users*. This classification, perhaps the most up to date and complete of all the classifications, is explained in more detail in 2.2.1 section.

2.2 Differences between novices and experts

According to Coe (1996), there are great differences in how novices and experts perceive and used software applications. On the one hand, novices' mental model has not improved through the experience, because an inexperienced user has not had enough practice and information to evolve their notion of how the system works. They are generally more focused on how to deal with the interface. In addition, their comprehension of the application functionalities is incomplete suggesting that an explicit assistance might be valuable to build a more suitable conceptual model, providing help and support in case of mistakes. On the other hand, experts have a refined mental model based on their experience. It provides a good mechanism for observing and dealing with problems during interactions, requiring, in comparison with novices, less amount of guidance and help.

From an HCI perspective, the usability component of the interface is applicable especially on both types of users. For novices, the ease of use is an indispensable step to go forward in the interaction. For experts, usability represents the speed of access and affordability to the functionality with less or no effort. Citing Hartson (1998):

The common saying of 'Lead, follow, or get out of the way', can be successfully applied to interface design for all type of users: Novice through task performance; Intermediate with informative feedback; and get out of the way of Expert users.

These expert vs. novice differences have been noticed in other disciplines, such as Psychology. Ever since the seminal studies of eye-gaze distributions over pictorial scenes (Yarbus, 1967), it has become increasingly clear that although a viewer may see the same scene multiple times, the pattern of gaze over the scene changes profoundly with task's goal, familiarity and experience. Prolonged viewing (Antes, 1974; Buswell, 1935) showed that later fixations in a scene tended to be longer. However, expertise in a skill such as music reading can be revealed by more nuanced analysis of gaze allocation over time. Land and Furneaux (1997) established that the novice piano player could look ahead around 2 notes to the right on a stave of music of where their hand was playing in the melody. Experts however expanded this look-ahead scope to 4 or 5 notes. Thus, it is the temporal differences or separations between actions and gaze location that are the key to reveal expertise via eye-movements. The expert is able to look beyond the task at hand to the next action when they are fluent in the task (the eye leads the hand). This temporal look ahead has been found for everyday tasks such as making tea

(Land, Mennie and Rusted, 1999), goalkeeping in football (Savelsbergh, Williams, Van Der Kamp & Ward, 2002), cricket (Land & McLeod, 2000) and playing chess (Reingold, Charness, Pomplun, & Stampe, 2001). Some of this look ahead is at least accounted for by anticipation. In other areas, some more skilful aspects of vehicle control have been revealed through analysis of expert driver's gaze (i.e., Land & Lee, 1994; Land & Tatler, 2001). More recently (Crundall, Chapman, Phelps & Underwood, 2003; Underwood, Chapman, Brocklehurst, Underwood, & Crundall, 2003) there have been found differences in the eye-movement strategies used by novice versus expert drivers. The sequence of gaze alternations between near and far changes with experience, with an overall increase in situational awareness observed for expert drivers. These differences have been also observed in learning environments. Recently, the oculomotor behaviour of people engaged in learning skilled physical tasks has been observed. The study by Foerster (Foerster, Carbone, Koesling, & Schneider, 2011) documented the increasing use of look ahead behaviour and a corresponding reduction in fixations on irrelevant or unused information during a high-speed bi-manual repetitive stacking task. This change in scan-path during task learning is argued to reflect a change towards the use of long-term memory as a control of attention once the task has become automated.

There is also HCI research about how expertise is reflected in eye movements during technology interaction. For instance, Crosby (Crosby, Scholtz, & Wiedenbeck, 2002) used recognition and timing methodologies studying comprehension on programmers. He found that novices discriminated very little between areas of the program and thus do not seem to use *beacons* (i.e., stereotypical segments of code). In contrast, more experienced programmers tended to concentrate on the important areas of a program. Kasarskis, Stehwi, Hickox, Arctz, & Wickens (2001) examined visual scanning characteristics of novice and expert pilots during landings. Among other conclusions, it was found that experts paid attention to strategic factors that allowed them to land more precisely. In virtual environments, Law et al. (Law, Atkins, Kirkpatrick, & Lomax, 2004) compared novice and experts in virtual laparoscopic surgery. The results from eye gaze analysis showed that novices needed more visual feedback of the tool position to complete the task than did experts. In addition, the experts tended to maintain eye gaze on the target while manipulating the tool, whereas novices were more varied in their behaviours and having more errors.

2.3 Differences between novices

In contrast with the fine-grained descriptions of *intermediate* (Lathanum & Wiedenbeck, 1993) and *expert* users described in the literature, definitions of the novice user category, if found, were characterised by their incompleteness. Behind the term of novice or naïve user, there are slight but important semantic and functional differences that make obligatory a deeper analysis for a clearer distinction of

what makes a user to be classified as a novice and the implications for such categorisation.

For instance, Shneiderman (1980, 2005) defines two type of beginners: *novice* and *first-time* users, who are assumed to not have knowledge about using the system and probably little knowledge about computer issues. Whereas *novices* have shallow knowledge about the task concepts, *first-time users* know the task concepts. Therefore, he attributed them an important feature, *professionalism*, which will have similarities connected, in some extent, with the definition of Lough and Burn (1977).

There is another difference; it occurs when the novice user does not have any ICT experience. In this case, their characteristics and potential requests are generally not gathered (for an exception see Shneiderman's 2005 classification) in classifications, designed in the era of databases and focused on users with an existing knowledge about the task or the programming language, necessary to be able to use the technology on those days. Wilson (1999) defined the user who did not implicitly have any technology experience and went one step further:

who may be not only technologically naïve, but also fearful of the technology.

In literature, such a user might be termed as a *technophobe* (Pirsig, 1974), or, in history, more pejoratively as a *luddite* (Hobsbawm, 1952). The cases described previously are not 'exceptions'. They represent particularities or differences between novices who may be erroneously grouped under the same user category.

2.4 Occasional use

To build a constructive and trustworthy definition for the OU, an in depth analysis of 19 previous classifications of users is presented, underlining points in common with the OU.

2.4.1 Analysis of users without experience in previous classifications

To evidence the range of previous work on users without experience with a system, a uniform approach across different authors is next presented (see a summary at the end of this paper, Table I, p. 15). The aim is to underline coincidences and divergences on the variables on which they based their categorisation of users in general and inexperienced users in particular. The first eight descriptions are extracted from Cuff (1980). Cuff's research is considered as a seminal work about inexperienced or casual users. He explored the definition of the term casual user in other authors, introducing new characteristics and guidelines for design.

- Martin 1973
See p. 4, section 2.1.
- Codd 1974

He defined a casual user based on the irregularity presented in the frequency of interactions with the system. Job or social reasons were excluded in the motivations for such use. This user was not versed in

computers, programming or any technical procedural aspects.

- Mann 1975

Contrary to the common practice at that time, he argued that command language should be only addressed to professionals or heavy users, who have experience using it. Therefore, command language was not recommended for computer-naïve users because it did not solve the obstacles they would find while using computers.

- Shapiro and Kwasny 1975

They defined casual user in terms of novelty by the unfamiliarity with part or the whole system. It was defined as an infrequent user who did not like short and unexplained computer input and output, such as *yes/no* prompts or imprecise menus. He pleaded for applications which could understand natural language, to explain the unfamiliar part of the system to casual users but also to frequent users who want to acquire the knowledge to use it in a quick way.

- Zloof 1975, 1978

In first instance, he described the non-professional user who did not have computer or mathematic background. Three years later he refined the concept for a person without a programming background who could be a professional in other field rather than computing. In contrast with Codd 1974, job and familiarity with the application were the motivation for the use. That user had to be ready to learn formal language and relational models. He enumerated profession examples to which casual users would typically belong: secretary, clerk, engineer or analyst.

- Kennedy 1975

He determined that the computer naïve has a limited knowledge about the system, which is based on records, lists or files. Cuff (1980) described the implications of such definition adding that a user's mental model of the computer system is based on *pre-computer concepts*, identifying so a key aspect of casual users. The familiarity with the system functioning and the training on it would evolve the original mental model.

- Lough & Burns 1977

In line with the second definition of Zloof 1978, for them casual users were professionals in a field other than computing, such as managers, lawyers or planners. However, they stated an important difference: those users did not want to know the intricacies of the system and neither should be required to learn data model, methods or programming issues. They included those users who used the system on a random basis, i.e., bank tellers or insurance company clerks, doing the same routines, having a well structured set of needs and allowing to have formal queries for such repetitive use. The influence of the frequency of use in the learning procedures of the system use was clear.

- Bjerre 1977

He defined the casual user who occasionally used the system only to extract some data and who did not have to have any programming skills.

- Cuff 1980

He explicitly avoided cataloguing the casual user – *no definition will come from this study*. In contrast, he analysed the casual user interpretations in other authors, through which he proposed a list of features that characterises this type of user.

With a set of attributes, he roughly modelled a class conveniently labelled as *casual user*. Despite the internal variety among this kind of users, they share important features that are concretised in several requirements for the design of systems for this type of users: *Frequency of use*, *Skill level*, and *Familiarity*.

- Moran 1981

See p. 4, section 2.1.

- Vassiliou 1982

He based his classification on four different variables, grouped two by two. For syntactic knowledge, as it was described in Shneiderman's (see p. 4), he used familiarity with programming concepts for a user who was not afraid of computers and had acquired logical or algorithmic problem-solving abilities; and frequency of use to determine directly the acceptable amount of training. For semantic knowledge, the variables were application knowledge to measure the precision of the conceptual model the user had about the structure and contents of the database; and range of operations to describe how many different types of queries the user wanted to ask in the language. The casual user was that one with low grade in all those four variables described.

- Rutkowski 1982

He distinguished between professional and novice users, in the context of engineering and product market realising that

for the more-than-casual user, control-letter functions are much quicker; In this fashion both the novice or occasional user as well as the professional are well accommodated.

He advised that complex functionalities should be only assigned for users with more experience:

More complex functions may be handled in a more complex manner because these will typically be used by more experienced user.

Additionally, he also enumerated the type of user targeted in each stage of a product market release: *technical specialist*, *enthusiast* and *consumer*.

- Carroll 1982

His work was in the direction to define consistently the metaphor as a useful component of the interface for

all types of users and especially for those with little experience, as the *naïve users*.

He highlighted as an example of metaphor the office desktop, that effectively compare the system features with the physical work space, such as files and folders, and also referred to naïve and optional users (like the office principal).

- Shneiderman 1983
See p. 4, section 2.1 Differences between novices.

- Nielsen 1993
See p. 4, section 2.1, Traditional Classifications.

- Turoff 1997
As it was previously introduced, he distinguished and detailed a wide range of users, but the closest ones to no previous knowledge or ICT experience are his *novice user* and *casual user*.

The novice user is trying to learn in their first time. He also considers motivation as a key factor that decides whether the effort of learning is carried out or not and depends upon how the system is presented to the user. Another type of user was the casual user, that is not only an infrequent user but also, and more importantly, does not have any ambition to master the system and may often prefer to be led by the hand to accomplish what they need to do.

- Cooper 2007
Again he differentiated three types of users: *beginners*, *intermediates* (that are perpetual) and *experts*. He based his classification on the knowledge the user has about the product and its domain of application, by virtue of the frequency of use.

However, he considered that most users are neither beginners nor expert, because they tend over time to gravitate towards intermediates, depending on how frequently they use the application. Generally, beginners want to learn and improve, so they become intermediates very quickly. Sometimes, intermediates can use the product intensively, increasing their knowledge, reaching the level of experts. Conversely, if experts do not use the application for a large period of time, they can forget significant portions of what they knew, becoming intermediates.

3. Reflections upon the analysis of users without experience in previous classifications

From the set of the authors' classifications previously described (a summary of them can be seen in Table I and II, p. 15), a selection of common variables across the authors has been listed. These variables are described below to later examine their

suitability for the definition of and inclusion in a new category of user.

3.1 Extraction of common variables

A set of five most relevant variables across the mentioned analysed authors is shown:

- *Frequency of use*: the rate the use of a system occurred over a particular period of time in the past.
- *Skill level*: the capability a user has respect use of technology in general or computer related systems in particular.
- *Familiarity*: the user's acquaintance of the interface and analogous systems.
- *Motivation*: the reason that triggers the use of the system.
- *Cost of learning*: the effort necessary to achieve a sufficient level of knowledge to use the interface.

3.2 Traditionally omitted variables and the need for a new user category

Among the variables presented, the absence of certain specificity can be observed. For instance, a wider spectrum of values for *prospective use* has not been found across the classifications studied. Most of the authors looked at the frequency of use understanding a continuous use for granted. The fact that a user may not repeat the use of the same interface in the future has not been included in the values of the frequency of use, and this may have a serious impact on any classification.

It can be also argued that there is a lack of value for *experience* or *competence in a non-technological domain*. A minimum level of syntax knowledge was necessary to work effectively in the context of natural language and analogous syntaxes. From there resulted the rationale of including novice users with certain experience on programming languages, because even the most inexperienced user had to deal with commands to extract the information and be able to work. An exception is Martin, who considered the particular case of users with no programming background at all. He called them intermediary users; those who had to delegate in other users with sufficient knowledge to extract such information (Martin, 1973). However, actual users do not have to commonly deal with databases with complex information extraction. There is still the possibility to deal with databases through command languages, but each day more easy-to-use access using other interaction styles, such as forms or direct manipulation, break the barrier of programming experience requirement.

Another aspect found is the set of different terms used to refer to the *infrequent user* concept: *naïve*, *first-time*, *novice*, *casual*, *intermittent*, *discretionary*, *irregular*. Not all of them are equivalent. For example, a first-time user may not use the system ever again, and thus not being catalogued as infrequent. This reflects the amalgam of concepts enclosed in the different terminology, and the need of a clear organisation of these categories and their variables that distinguish them, especially regard novices. A distinction of a

category of users based on their frequency of use is shown, inferred from the traditional classifications of users analysed, from lowest to highest and from left to right:

$$\text{First-time} \leq \text{Infrequent} < \\ \text{Frequent} \leq \text{Expert}$$

This means that the first-time user is a particular case of an infrequent user.

The main difference between them is the intention of the *prospective use*. The frequent user is likely to use the system in near time, and interested in proficiency and learning, to lessen interaction times and find the effortless ways to achieve goals. By contrast, for the infrequent user, achievability and time elapse become priority instead of learning.

Moran (1981) argued that learning of the interface is as important as being able to do the task. Therefore, the time taken to do the task is relegated to an inferior priority:

Learning is, of course, paramount for the novice whereas the time it takes to do a task is secondary – getting the task done at all is the big concern.

However, it seems that this is not the case in contexts where learnability does not have the same level of importance than time elapsed. On the contrary, many users just wish to proceed with the task at hand in case where time is critical, i.e., purchasing a train ticket in a self-service train ticket machine for the train about to depart. There are two conflicts considering these type of contexts. On the one hand, there is an aim to accomplish the transaction as quickly as possible. On the other, there may be an awareness that future interactions may be faster if user spends some time to learn the task during the transaction. In the latter, individual differences account for different willingness to take the extra time to learn, and, in addition, uncertainty about the likely number of future interactions may also inhibit the choice of learning. Some questions arise: What if that prospective use is not going to happen, or not with a fair probability? What if the use is the first and last use, unique? In such cases, to learn how to use the application is as important as just using it. The priority is thus to achieve the goal. For instance, in the previous case of buying a train ticket to take a train about to depart, the time the interaction takes is critical, becoming the most important goal, more important than the learning during the interaction which may be not repeated in the future.

4. The Occasional User: Characteristics and variables

The increasing weight of usability and accessibility in the design of digital systems respond to the proliferation of new types of devices and new scenarios of use (i.e., mobile devices such as smartphones and tablets; SST such as self-service checkout or airport-check in) that redefine the traditional relationship between user and technological devices. Users interaction is no longer based only on simple data

process/extraction; rich interactive dialogs present quite different goals such as: buying tickets in a train station ticket machine, obtaining a boarding pass at airport-check in machine, a first time web transaction, being guided to the nearest located ATM by a specific-purpose mobile application.

This type of interaction is described as a occasional, and OUs those who carried it out. The OU is a type of user without previous experience nor knowledge about a concrete interface and whose main priority is to use the system and achieve his goals without cost on time or effort. The key points of OU interaction are guidance during the process and assistance in case of error, without requiring from the user a previous knowledge to use the interface. For that, spending time in learning how to use the interface is futile as they ignore if they are going to use again the interface in the future. These premises respond to the recurrent case where instead of reading the instruction manual to use a new system, the inexperienced user appeals to the IT support officer: 'Show me, don't tell me.'

4.1 Characteristics and specific variables that define the OU

An OU has the following defined characteristics:

- very specific goals to accomplish;
 - unfamiliar with the application and its interface;
 - do not have previous knowledge or training on analogous interface that is to be used;
 - has only the time that the interaction elapses to know how to use it;
 - does not have any ambition to master the system (on the contrary), their goal is to accomplish what they need to do, and
 - there is no need nor expectation of any repeating use of it in the near future, neither for the learning by retention or experience.
- Accordingly, two variables associated with time are critical in understanding the OU: *experience on the interface* and *prospective use*.

The former, *experience and knowledge on the interface*, identifies the prior experience the user has with the interface. In case of occasional use the value is zero or near zero. This means that whether the user has had an encounter with the same or analogous technology, the difficulties they experience on learning and, in many cases, their absence of motivation, make it unwise to rely on user memory recall as the sole mechanism to recognise how to use the interface. It is recommended to consider that the user, then, faces an unknown interface.

The other variable, *prospective use*, is an explicit reference to the probability of the use of the same system by the same user in the near future. Because for an OU the likelihood of use in the future of the same interface cannot be inferred with fair level of probability, this constrains the probability to be near zero and always less than 1, and in terms of the implications to design for learning, near to zero.

Essentially, to the question of "Do you know if you are going to use the system again in the near future?" an OU would answer: "I do not know", or "Probably not". Therefore, the probability of prospective use

cannot be ever inferred to 1, and should be close to zero. This is a key difference with the most accepted category of Novice user, which implies that, even if it requires a learning period, the user intends to keep using the system beyond the first time (and that is why many times they are referred as first-time users) (Cooper, 2005).

In conclusion, the two parameters and their values that characteristically define a OU user are shown in Table II.

Table II. Identification Parameters for OU and their values

| |
|---|
| Experience and knowledge on the interface ≈ 0 |
| $0 \approx P(\text{prospective use}) < 1$ |

4.2. Implications of these variables in Interface Design for the OU

The selection of these variables has several important implications in the UID and interaction for the OU.

Learnability: the interface should be developed taking into account that the number of sessions the same user is going to perform is limited to 1. This means that possible future interactions are not accounted. Mechanisms of learning functionalities of the interface, by retention, or by repetition, are extremely limited. Instead of relying on the user to learn how to use the system, it is recommended to show the user how to achieve their goals. For it, the use of metaphor can be essential to establish intuitive links with the real world elements (as seen in Carroll, 1982).

Goalability: it refers to the importance of the goal achievement, which is the ultimate reason that explains why the OU is using the interface. Above all, the allowance and the path to achieve any goal and sub-goal should be clearly described, guiding the user where necessary, minimising the ambiguity and error probability.

Elapsed Time: the time user spends in using the interface to achieve their goals, or, in other case, to receive a helpful outcome from the system, should be as short as possible. Possible increments on time spent should be only allowed to ease the interaction, goals or assistance, i.e., extra screens or dialogue with a virtual assistant.

Guidance and Assistance: where possible, efficient mechanisms of guidance through the interaction should be provided. This aspect is addressed to compensate the deficiency on the learnability mechanisms previously described. For example, a dynamic assistant would lead the user throughout the interaction, informing in each step (i.e., *AGILE_reference*) in a similar way that other software applications, called *wizards*, do during the installation of a software application. Another recommendation would be to present a clear map of the interaction steps, informing the user about the progress of the process.

Recoverability and Error handling: there should be an effective help system in case of error or impossibility to achieve a goal. This aspect is related straight away with user's feedback, and will have an influence on the notion user takes from the interaction process.

In summary, OU are generally unaware of the low level details of the system used (i.e., software version, use of *emoticons*, customisable look and feel). Therefore OU's expertise requirement should be removed from the preconditions imposed in the development of OU interfaces. The potential benefit of designing for these users is that the interfaces can be potentially used by users with a wide range of expertise. The OU inherent characteristics of memory and learning require an interaction designed with agile mechanisms that make cognitively inexpensive UI use.

All these previous guidelines can be summarised in the following corollary: "The user interface for the OU should not require any prior knowledge".

4.3 Why the occasional user is not only an added category to traditional classification of users

It is essential to understand that this category of user is extended across the three most accepted ones regarding computer/technology knowledge: novice, intermediate and expert. This new category may be seen as a horizontal category, where each of the previous can fall into depending of the inherent circumstances of the user (see Fig. 2). If these circumstances, variables, comply with those expected for the OU of a specific application, the novice, intermediate or expert has to be classified and consequently treated as OU for this application. The implications of such new categorisation should be included in all stages of the system design, and also in the selection of the most appropriate interaction style for this type of user.

5. CONCLUSIONS AND FUTURE WORK

This paper has described the ordinary model of user that many UI designers have in mind, the *average user*. It has been questioned whether this stereotype truly reflects the current wide spectrum of users and whether it is ultimately useful for the design of an interactive system. Subsequently, a review of the traditional classifications of users was made to explore the variables in which such categorisations were based, to ascertain whether they covered the whole spectrum of current users. Because of the permanent change on the context where the technology is used and the constant evolution of user profiles, those commonly accepted classifications were revisited with a target update, to accommodate new trends and user profiles. Without discussing what sort of the approach was better for HCI interface design ((i) designing for one

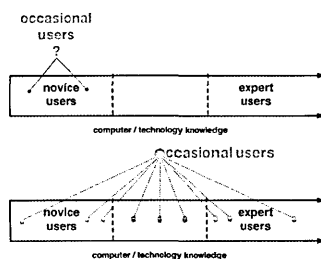


Fig. 2. Distribution of the OU (of a specific system or application) regarding to the classification of users with different levels of expertise with computer/technology. (a) Hypothetical distribution of the OU, placing them in the regions of novices or those with little knowledge. (b) Real distribution of the OU. The OU can be placed in any category across the three most accepted ones: novice, intermediate and expert.

uniform user group; (ii) designing different interfaces for different user groups; (iii) designing an adaptive interface (Aykin & Aykin, 1991)), the user has been placed as an essential component of UID. This work has proposed a revision of the user types, adding to the most accepted classifications and starting from the Cuff research a new type of user consistent with the new trends, technologies and interaction scenarios. This new type of user is named *Occasional User*. The main characteristics of the OU have been studied, presenting their implications in UID. Describing a new category of user provides a valuable information for UI designers and HCI community.

The lessons learned from the OU are directly applicable in UIs where the use of the system depends on circumstances out of the control in the time of design, for example, the decision made by a first-time customer whether repeating the use of a Self-Service Checkout based on the outcome of their encounter. In commerce scenarios like this, where the success of a business is to maximise the probability the customer is going to return, the OU has the potential to become a regular user-customer. However, in case of error, they may hold up the process and complain about the experience. They may become a problematic customer whether they are not attended correctly and their problems not solved. They may well be cash rich and time poor, meaning that they can cause UI designer and business owners numerous problems if their needs are not addressed in a successful way. Bottlenecks and problems caused by sub-optimal interactions change opinions about organisations. A further problem is that many of the host organisations do not look for these problems and are not necessarily able to find them. For example, the international supermarket company Tesco does not necessarily want to divulge the number of walk away from their self service tills, to not divulge to their partners how much business they were losing. The OU is an essential type of user to apply user-centred design (UCD) approach that understands the interaction

as universal, accessible and transparent for the user, no matter the technological era we are in.

The increasing number of mobile devices and expansion of new context of use (indoor, outdoor, public space) is multiplying the number of potential users who want to use the technology but without being required an extensive knowledge of computer/technology concepts and UIs. Design interfaces for this type of users is a challenge because traditional mechanisms of learning are not applicable under these circumstances. However, alternative ways of guiding the user to accomplish their goal can be implemented (AGILE reference).

The development of adequate interfaces for OUs is in the agenda of the authors. In addition, this type of interface for occasional use, can inclusively gather other types of users requirements. Those that, for instance, feel comfortable with the idea of not having to remember how to operate the interface. Instead, a guidance throughout the interaction is provided in each step, relieving the user from having to memorise specific functionalities and understand foreign task domain concepts.

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TABLE I. VARIABLES EACH AUTHOR EMPLOYED TO CLASSIFY USERS

| N | Author | Year | Parameters used to establish the classification of users | | | | |
|----|------------------|------------|--|-------------|-------------|------------|------------------------------|
| | | | Frequency of use | Skill level | Familiarity | Motivation | Technical Knowledge Required |
| 1 | Martin | 1973 | x | x | x | | |
| 2 | Codd | 1974 | x | x | | x | |
| 3 | Mann | 1975 | x | x | | | |
| 4 | Shapiro & Kwasny | 1975 | x | | x | | |
| 5 | Zloof | 1975, 1978 | | x | x | x | x |
| 6 | Kennedy | 1975 | | x | x | | |
| 7 | Lough & Burns | 1977 | x | x | | x | x |
| 8 | Bjerre | 1977 | x | x | | | |
| 9 | Cuff | 1980 | x | x | x | | |
| 10 | Moran | 1981 | x | x | | | x |
| 11 | Rutkowski | 1982 | x | | x | | |
| 12 | Vassiliou | 1982 | x | | x | | x |
| 13 | Carroll | 1982 | x | x | x | x | |
| 14 | Shneiderman | 1983, 2005 | x | x | x | | |
| 15 | Nielsen | 1993 | | | | | |
| 16 | Turoff | 1997 | | | | | |
| 17 | Cooper | 2007 | | | | | |

TABLE II DEFINITIONS EACH AUTHOR EMPLOYED TO CLASSIFY USERS AND THEIR CASUAL USER DEFINITION

| Author | Year | Closest definitions to the Occasional User |
|------------------|--------------|---|
| Martin | 1973 | Occasionally use of computer |
| Codd | 1974 | Irregular interactions, such as occasional extracting of data, and not motivated, not versed in computers and technical aspects |
| Mann | 1975 | Naïve user (vs. computer professionals and heavy users) |
| Shapiro & Kwasny | 1975 | Facing new system and unfamiliar with system and dislikes prompts and imprecise menus |
| Zloof | 1975 1978 | Non-programmer, motivated by job |
| Kennedy | 1975 | Computer naïve |
| Lough & Burns | 1977 | Professional in some field other than computer, with no need to learn data model or access methods |
| Bjerre | 1977 | Occasional extracting of data |
| Cuff | 1980 | No computer experience |
| Moran | 1981 | Novice with assured prospective use of same application |
| Rutkowski | 1982 | Novice without complex functionalities |
| Vassiliou | 1982 | Non-extensive familiarity and narrow range of operations intended and low grade on Sheniderman's syntactic and semantic knowledge variables |
| Carroll | 1982 | Naïve = no domain experience + no training on data processing |
| Shneiderman | 1983 | Novice = no syntactic knowledge + little knowledge about computer semantics + professional on task domain + assured prospective use of same application |
| Shneiderman | 2005 | True Novice = no syntactic knowledge + No knowledge about computer semantics + professional on task domain + assured prospective use of same application |
| Nielsen | 1993 | Novice = computer experience but no application experience, need to learn interface use from the beginning Complete novice = novice without computer experience |
| Turoff | 1997 | Novice = learning for the first time a new system or a part of it Casual user = use the system only a few times a week or less, without any ambition to master the system. They are continuous novices |
| Cooper | 2007 | Beginners without interest to learn and improve |

Glossary

| | |
|-------------------------------|---|
| Accessibility: | The degree to which a product, device, service, or environment is available to as many people as possible. |
| Adobe Flash: | Software platform used for authoring of vector graphics, animation, games and rich Internet applications (RIAs). |
| AGILE: | Assisted Guided Interaction for no Learning nor Experience required. |
| AI: | Artificial Intelligence. |
| Animation: | Discipline that studies the technique of creating successive drawings, positions of puppets or electronic images or models to create an illusion of movement when they are shown as a sequence. |
| ANOVA: | Analysis of Variance. A collection of statistical models used to analyze the differences between group means and their variation among and between groups. |
| ATM: | Automatic Teller Machine. |
| BeGaze: | Eye Tracking Software to visualize, analyze and export eye tracking data by SMI Sensomotoric Instruments. |
| Bonferroni Correction: | It is a method used to counteract the problem of multiple comparisons. It is considered the simplest and most conservative method to control the family wise error rate. |
| CAP: | Common Accessibility Profile. |
| Cognitive Psychology: | Cognitive psychology is the branch of psychology that studies mental processes including how people think, perceive, remember and learn. |
| Cue: | A feature of something perceived that is used in the brain's interpretation of the perception. |
| DS: | Digital Signage. |
| DV: | Dependent Variable. |

| | |
|-----------------------------|---|
| Ecological Validity: | The potential utility of various cues for organisms in their ecology (or natural habitat) (Hammond, 1998). |
| Friedman Test: | Non-parametric statistical test by one-way repeated measures analysis of variance by ranks. |
| GOMS: | Goals, Operators, Methods, Selection. |
| GUI: | Graphical User Interface. |
| HCI: | Human-Computer Interaction. |
| ICF: | The International Classification of Functioning, Disability and Health. |
| ICT: | Information and Communication Technology. |
| Inclusive Design: | The design of products and/or services that are accessible to, and usable by, as many people as reasonably possible without the need for special adaptation |
| IView: | Eyetracker software package. |
| JPL: | Jet Propulsion Laboratory. |
| Likeability: | The quality of being likeable. |
| Likeable: | Pleasant, or appealing. |
| \overline{M} : | Mean. The result obtained by adding several quantities together and then dividing this total by the number of quantities. |
| MS: | Microsoft. |
| NASA: | National Aeronautics and Space Administration. |
| OU: | Occasional User. |
| P(<i>i</i>): | Probability of occurring event <i>i</i> . |
| Precue: | Cue performed before the occurrence of a specific event. |

| | |
|-----------------------------------|--|
| RL: | Response Latency. It is the time recorded from the show of the stimuli until the participant makes a response. |
| SD: | Standard Deviation. It shows how much variation or dispersion exists from the average (mean), or expected value. |
| SE: | Standard Error. It is the standard deviation of the sampling distribution of a statistic. |
| SSCI: | Self-Service Check-in. |
| SSCO: | Self-Service Checkout. |
| SST: | Self-Service Technology. |
| ToM: | Theory of Mind. |
| UARM: | Universal Access Reference Model. |
| UCD: | User-Centred Design. |
| UI: | User Interface. |
| UID: | User Interface Design. |
| US: | United States. |
| Usability: made object. | is the ease of use and learnability of a human- |
| VA: | Virtual Agent. |
| Valley of Eeriness: | Synonym of Uncanny Valley. It is a hypothesis in the field of human aesthetics which holds that when human features look and move almost, but not exactly, like natural human beings, it causes a response of revulsion among human observers. |
| WIMP: | Windows, Icons, Menus, Pointer. |

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